AD-A154 713 INSTALLATION RESTORATION PROGRAM PHASE I: RECORDS SEARCH GOODFELLOW AIR FORCE BASE TEXAS(U) ENVIRONMENTAL SCIENCE AND ENGINEERING INC DENVER CO MAR 85 1/2

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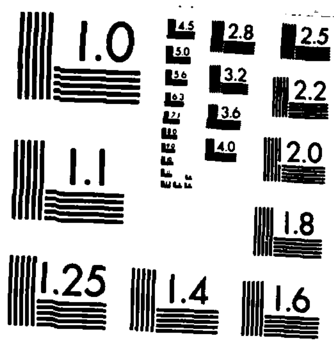

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A154 713

INSTALLATION RESTORATION PROGRAM
PHASE I: RECORDS SEARCH

GOODFELLOW AIR FORCE BASE
TEXAS

Prepared for:

UNITED STATES AIR FORCE
HQ AFESC/DEVP
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and

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F08637-83-G-0010

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Denver, Colorado

March 1985

NOTICE

This report has been prepared for the U.S. Air Force by Environmental Science and Engineering, Inc., for the purpose of aiding in the implementation of the Air Force Installation Restoration Program. It is not an endorsement of any product. The views expressed herein are those of the contractor and do not necessarily reflect the official views of the publishing agency, the U.S. Air Force, or the Department of Defense.

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EXECUTIVE SUMMARY

The Department of Defense (DOD) has developed a program to identify and evaluate past hazardous material disposal sites on DOD property, control the migration of hazardous contaminants, and control hazards to health or welfare that may result from these past disposal operations. This program is called the Installation Restoration Program (IRP). The IRP has four phases consisting of Phase I, Initial Assessment/Records Search; Phase II, Confirmation and Quantification; Phase III, Technology Base Development/Evaluation of Remedial Action Alternatives; and Phase IV, Operations/Remedial Actions. The IRP will be the basis for response actions on Air Force installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, Executive Order 12316, and 40 CFR 300 Subpart F (National Oil and Hazardous Substances Contingency Plan). CERCLA is the primary legislation governing remedial action at past hazardous waste disposal sites. Environmental Science and Engineering, Inc. (ESE), was retained by the United States Air Force to conduct the Phase I, Initial Assessment/Records Search for Goodfellow Air Force Base (GAFB) under Contract No. F08637-83-G0010-5007.

METHODOLOGY

The methodology utilized in the GAFB records search began in September, 1984 with a review of past and current industrial operations conducted at the base. Information was obtained from available records, such as shop files and real property files, as well as interviews with past and current base employees from the various operating areas. The next step in the activity review was to determine the past management practices regarding the use, storage, treatment, and disposal of hazardous materials from the various operations on the base. A ground tour of the identified sites was then made by the ESE Project Team to gather site-specific information. A decision was then made, based on all of the above information, regarding the potential for hazardous materials contamination at any of the identified sites.

INSTALLATION DESCRIPTION

GAFB is located in West Central Texas in Tom Green County, Texas, within the southeastern city limits of the City of San Angelo. Major highways include 277, 87, and 67, all of which intersect in San Angelo. The nearest major metropolitan areas are Fort Worth, 250 miles to the northeast, and San Antonio, 210 miles to the southeast.

At present GAFB encompasses approximately 1,139 acres. Boundaries have changed frequently in the past, and numerous areas within the main installation as well as auxiliary airfields have been excessed.

Overall command of GAFB rests with Headquarters 3480th Technical Training Wing. The wing exercises all managerial, operational, and maintenance training needed to fulfill the base cyptologic and communications security missions. In addition to conducting the required training programs, the wing also maintains the GAFB physical facilities and provides support services through the 3480th Technical Training Group, the 3480th Air Base Group, and the USAF clinic.

ENVIRONMENTAL SETTING

The climate of the San Angelo area is classified as semi-arid with warm, dry weather predominating. Precipitation averages approximately 21-inches per year (in/yr), with an average of about 18.5-inches (in) of rainfall and 2.5-in of snowfall. September is generally the wettest month, December the driest. The average annual temperature is 65 degrees Fahrenheit (°F). January is the coldest month with an average temperature of 47°F. July is the warmest month, with an average temperature of 85°F. The area experiences an average of 232 frost-free days. Winds average 11 miles per hour (mph) on an annual basis. Winds generally come from the south-southwest sectors.

GAFB lies just off the northeastern edge of the Edwards Plateau, within the rolling plains physiographic province. The topography of GAFB can be characterized as level to very gently rolling. The range of surface elevations is relatively small, and no significant relief occurs on the base.

Elevations range from 1,840 feet (ft) in the northern portion of the site to 1,880 ft in the southern portion of the base. The airfield area which comprises a large portion of the site is especially level due in part to airfield construction and maintenance. The cantonment area is only slightly more rolling in topography.

No well-developed natural surface drainage features are within GAFB. Drainage is generally accomplished by a system of stormwater drainage ditches receiving surface runoff from the surrounding land area.

Precipitation is the source of ground water recharge in the area of GAFB. Recharge to the major aquifers occurs mainly through direct infiltration of precipitation on the land surface and by streamflow across outcrop areas. The intergranular pore space of the sandstones and unconsolidated alluvium and the joints, crevices, and solution openings of the carbonates represent a network which readily permits infiltration of ground water.

Discharge of ground water to the surface is accomplished through springs and seeps, by evapotranspiration where the water table is near the surface, and by wells. Ground water movement in the area of GAFB is generally towards the Concho River and its tributaries. Local variation may occur due to the pumping of wells for irrigation and livestock purposes.

Information regarding ground water supply and occurrence at GAFB is limited as no water wells have ever been completed on the base. One borehole completed in the southeast corner of the base did encounter water and indicates a water-bearing zone at 75 ft below the surface. The borehole appears to have produced water from a conglomeratic sequence in the Permian Choza Formation. The aquifer is semi-confined as the water column rose some 24 ft above the water-bearing unit. An examination of data regarding water wells in the proximity of GAFB further substantiates the presence of the aquifer in the area. Water level measurements from the wells indicate the water table to be at 34 ft to 76 ft below land surface.

Biota characteristics of GAFB are typical of maintained/landscaped areas of west-central Texas. Habitats are a combination of lawns and landscaped areas (cantonment area) and more natural grassland/weed habitat (airfield and perimeter). Habitats of value to wildlife are essentially non-existent on GAFB.

No threatened or endangered species are known or likely to occur on GAFB. Existing activities and operations are not known to have any impact on existing habitats or wildlife.

FINDINGS

Current industrial operations at GAFB are very limited. Vehicle and aircraft maintenance is limited to maintenance of base vehicles at the Transportation Motor Pool, maintenance of private vehicles at the Auto Hobby Shop, and maintenance of aircraft operated by the Aero Club. The only other industrial operations are the facilities maintenance shops operated at 3480th Civil Engineering Squadron (CES); the Morale, Welfare and Recreation (MWR) Photo Hobby Shop; Reproduction, and Computer Maintenance at the Security School.

The GAFB mission underwent a major change in 1958. At that time, command of the base was transferred from Air Training Command (ATC) to USAF Security Service. This terminated the flying mission at GAFB, which had operated as a basic pilot training school since 1941. This change resulted in a drastic drop in the level of industrial operations.

Before 1958, the pilot training and support units at GAFB provided a full range of aircraft maintenance including painting, engine repairs, and aircraft systems maintenance. These operations were concentrated in the three main hangars along the flightline, which have since been converted to other uses.

Training at GAFB is limited to that provided by the Security School. Firefighter training exercises involving live fires are conducted at an off-base facility operated by the City of San Angelo.

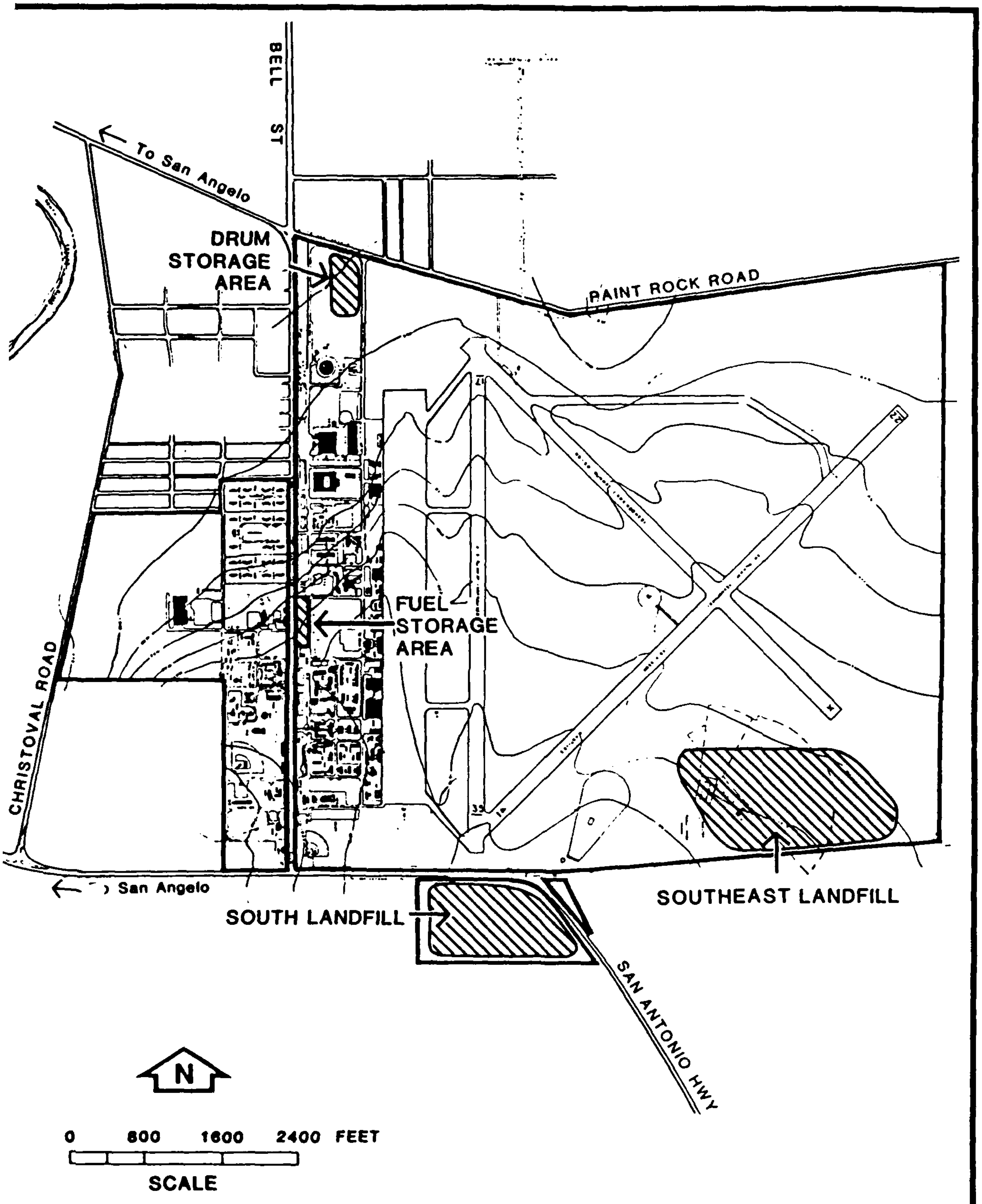
GAFB personnel provided a current list of industrial operations and waste generation. Based on this listing, GAFB has applied for nonhandler status under State of Texas regulations, indicating that existing operations are not generating wastes which qualify as hazardous under RCRA. Due to the limited extent of industrial operations, waste production is limited to waste oil, spent solvent, and paint waste. Interviews were conducted with personnel from each of the waste-generating operations to confirm waste quantities and disposal methods.

The general trend over the years since GAFB began operations has been from largely unsegregated disposal in base landfills to contract disposal. Before 1960, containerized liquids were routinely buried in base landfills. Over this same period, the firefighter training area was used as a general dumping ground for fuel, oil, and solvents. This area was later incorporated into the landfill.

When the GAFB flying mission ended, waste generation presumably dropped dramatically. Thus the incidence of industrial waste landfilling dropped as well; however, base landfills continued to be used as disposal sites for virtually all wastes into the 1970's. At that time, waste segregation was initiated. Most industrial waste began to be collected in drums for disposal through Defense Property Disposal Office (DPDO). Isolated incidents of disposal in landfills and oil spreading for dust suppression continued until approximately 1980.

In 1982, the base landfill was closed to general use. Since that time, on-base waste disposal has been limited to the disposal of construction rubble and fill dirt.

One known PCB spill has occured at GAFB. The incident occured in the vicinity of Building 511. Clean up and removal activities were in progress during the site visit. This study identified four areas at GAFB subject to contamination by industrial and/or hazardous waste as a result of handling and disposal practices. Figure ES-1 illustrates the location of these areas.



SOURCE: ESE, 1984

Figure ES-1
AREAS OF POTENTIAL CONTAMINATION

INSTALLATION RESTORATION PROGRAM
Goodfellow Air Force Base

2.3 ORGANIZATION AND MISSIONS

Overall command of GAFB rests with Headquarters 3480th Technical Training Wing. The wing exercises all managerial, operational and maintenance training needed to fulfill the base cyptologic and communications security missions. In addition to conducting the required training programs, the wing also maintains the GAFB physical facilities and provides support services.

These subordinate units are present on GAFB: the 3480th Technical Training Group, the 3480th Air Base Group, and USAF clinic.

The 3480th Technical Training Group is responsible for conducting training programs associated with the cryptologic security schools. The 3480th Air Base Group operates, administers, and maintains GAFB and its facilities and provides all support services.

2.4 MAJOR TENANTS

The following is a brief description of the major tenants (and missions) presently active on GAFB:

2081st Communications Squadron - Manages, operates, and maintains communications-electronic services in support of GAFB.

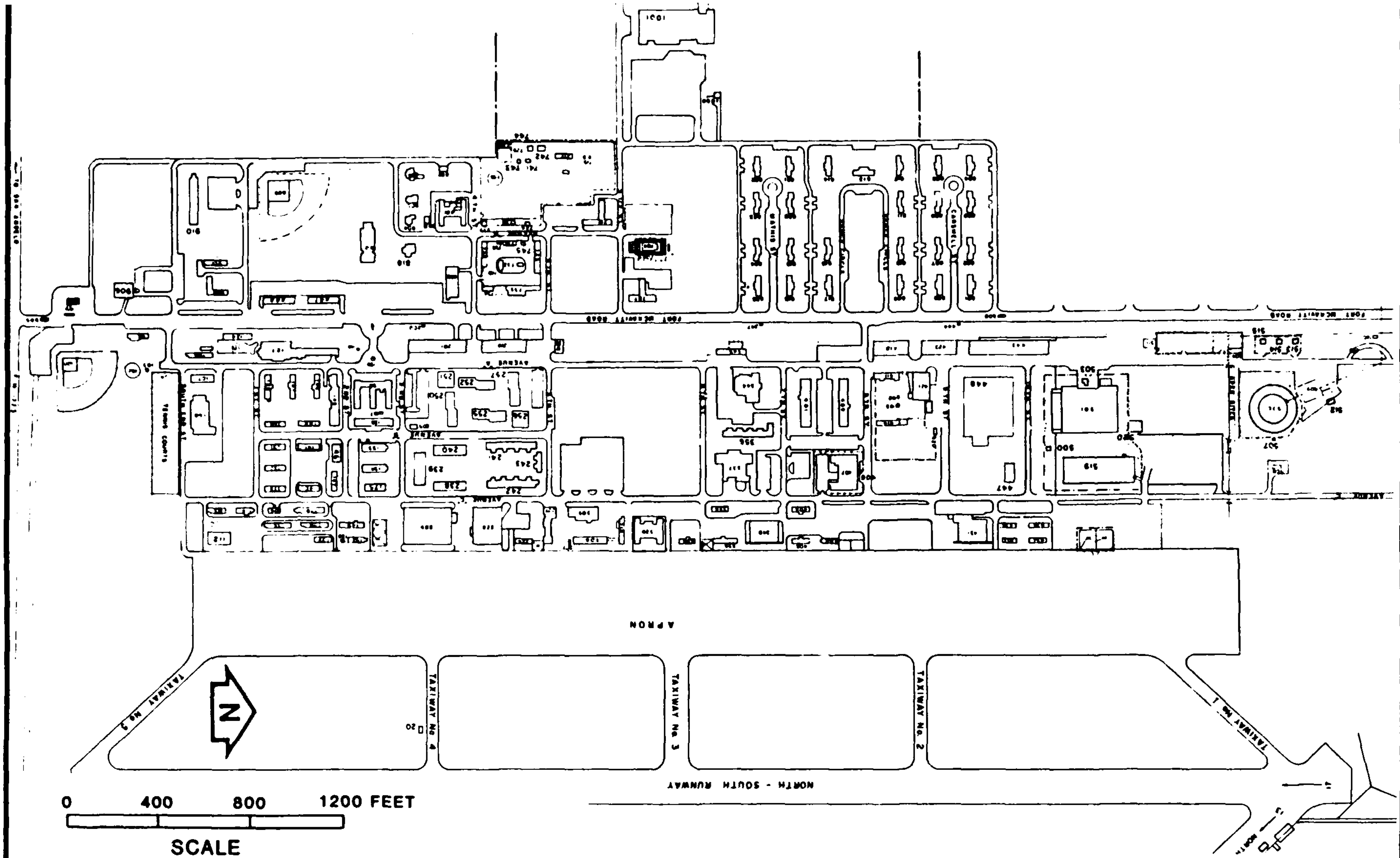
U.S. Army Intelligence Battalion - responsible for supervision, management, and support of all assigned and attached Army personnel.

Naval Technical Training Detachment - provides administrative and support services to Navy personnel reviewing training at or assigned to GAFB.

Defense Investigative Service - investigates military personnel requiring access to classified materials or equipment.

Detachment 1008, Office of Special Investigations - conducts investigations of fraud, counter-intelligence, and other criminal activities.

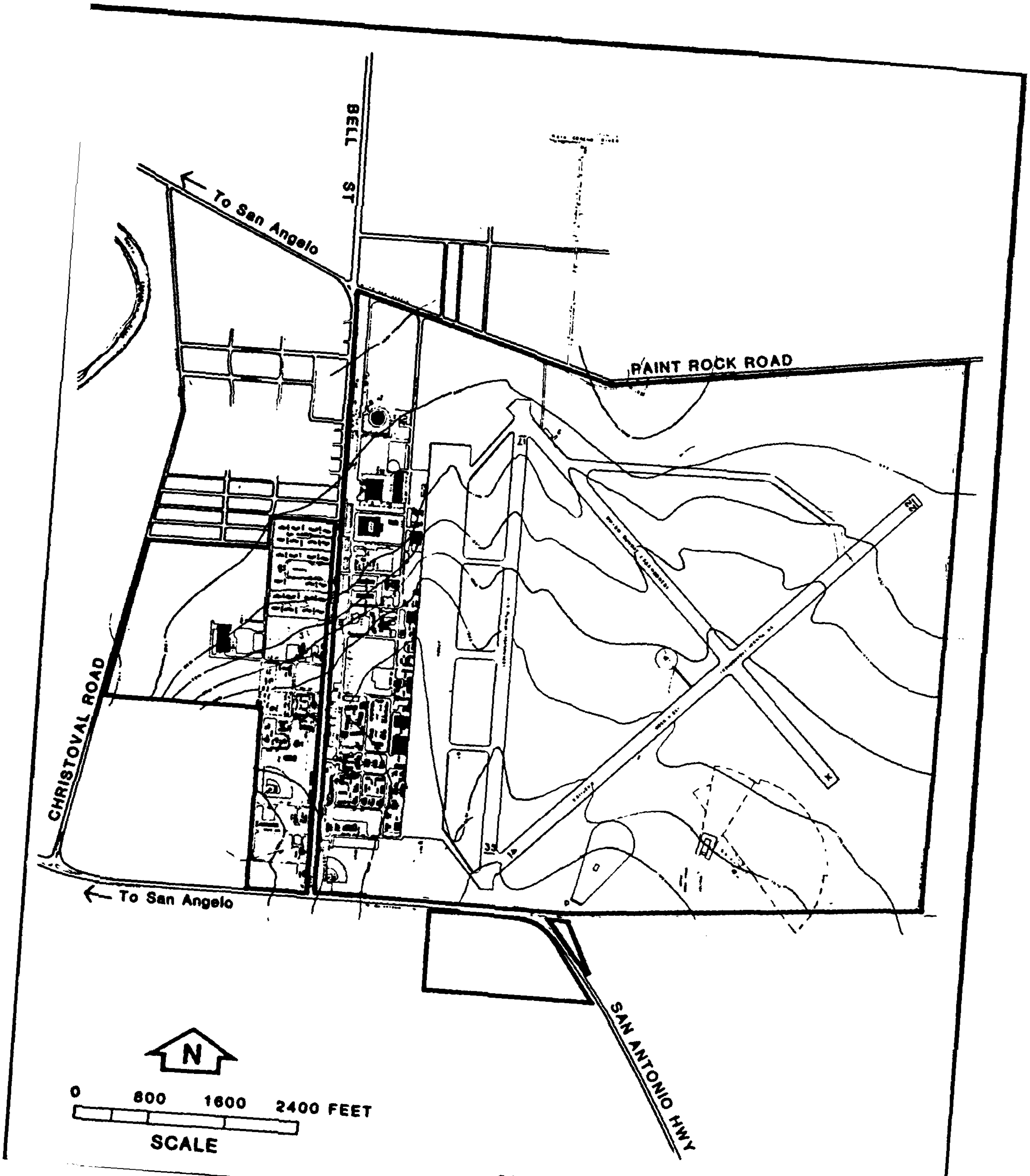
3314th Management Engineering Squadron - provides management advisory services to base operating officials; develops and tests various operating standards; establishes and reviews manpower requirements.



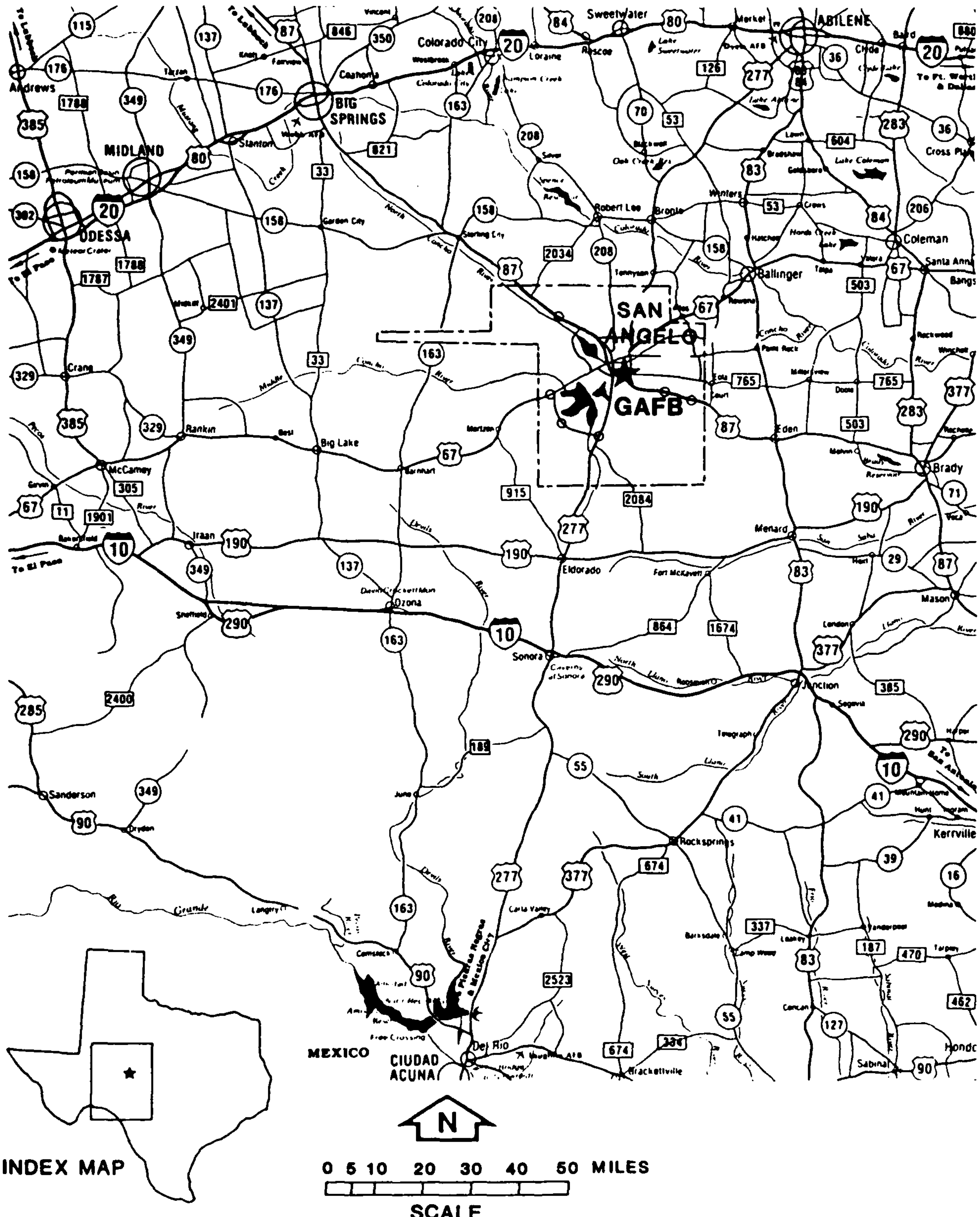
SOURCE: GAFB INSTALLATION DOCUMENTS, 1984

Figure 2.1-3
OPERATIONS AREA

INSTALLATION
RESTORATION PROGRAM
Goodfellow Air Force Base



SOURCE: GAFB INSTALLATION DOCUMENTS, 1984



SOURCE: ARMED SERVICES PRESS, 1984

Figure 2.1-1
LOCATION MAP- GAFB

INSTALLATION
RESTORATION PROGRAM
Goodfellow Air Force Base

2.0 INSTALLATION DESCRIPTION

2.1 LOCATION/SIZE

GAFB is located in West Central Texas in Tom Green County, Texas, within the southeastern city limits of the city of San Angelo (Figure 2.1-1). Major highways include 277, 87, and 67, all of which intersect in San Angelo. The nearest major metropolitan areas are Fort Worth, 250 miles to the northeast, and San Antonio, 210 miles to the southeast.

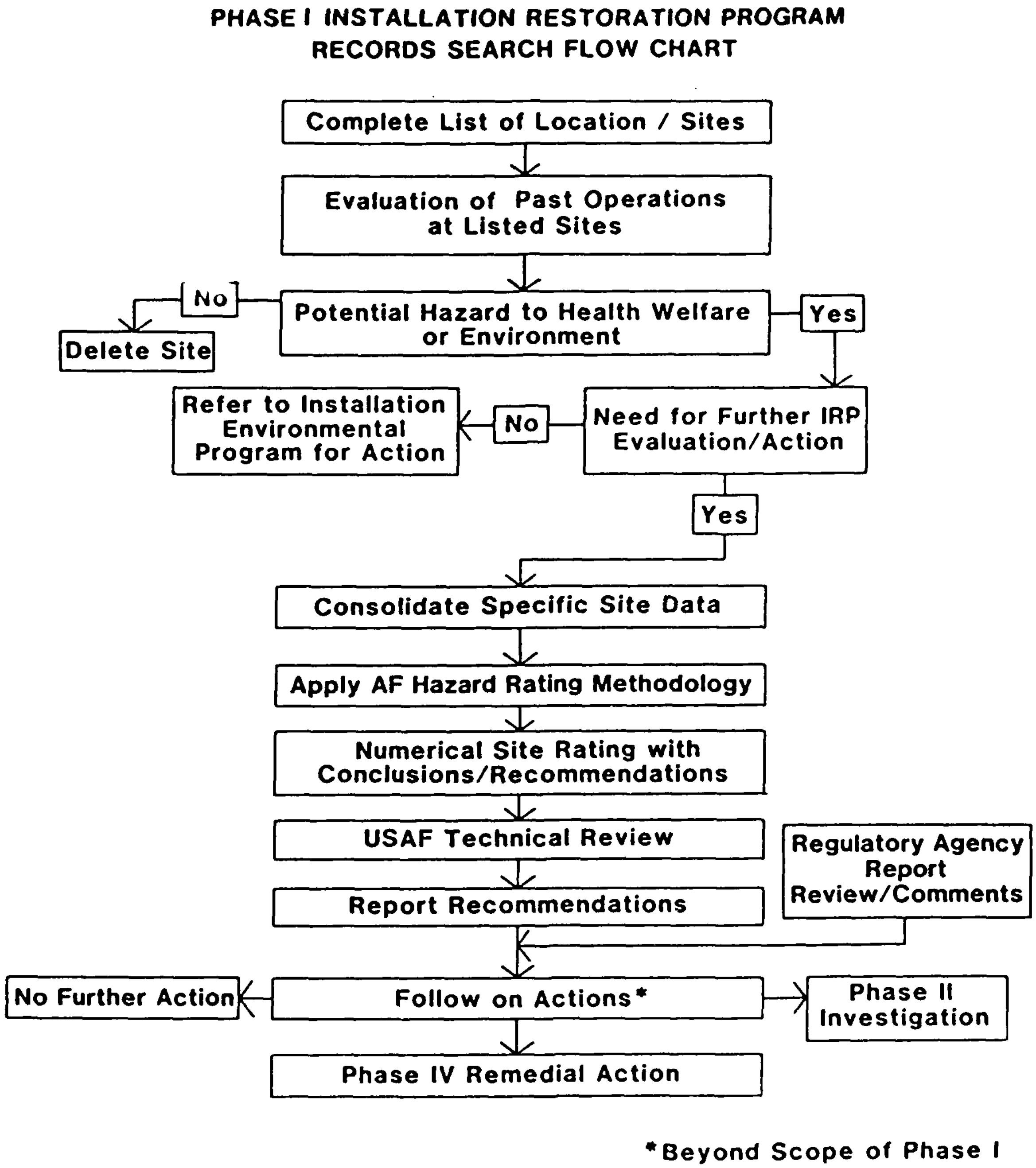
At present GAFB encompasses approximately 1,139 acres (Figure 2.1-2 and 2.1-3). Boundaries have changed frequently in the past (see Section 2.2) and numerous areas within the main installation as well as auxillary airfields have been excessed.

2.2 HISTORY

The following are key elements in the history of GAFB and its missions (GAFB, 1978).

1. In 1941, GAFB offically ope· d as a pilot training installation.
2. In 1945, GAFB was designated a primary flying school.
3. In May 1947, GAFB was placed on inactive status.
4. In December 1947, GAFB was reactivated as a basic pilot training school.
5. In 1958, GAFB command was transferred from ATC to USAF Security Service; flying mission terminated. USAF School of Applied Cryptologic Sciences began training at GAFB.
6. In April 1978, USAF announced that GAFB was a candidate for closure.
7. In July 1978, ATC assumed command of GAFB.
8. In 1981, GAFB was removed from base closure list.
9. In 1984, it was announced that GAFB will become the USAF Cryptological Training Center and a target for consolidated intelligence training.

Appendix D. The sites, which were evaluated using the HARM procedures, were also reviewed with regard to future land use restrictions.



SOURCE: AFESC, 1984

Figure 1.3-1
IRP RECORD SEARCH FORMAT

INSTALLATION RESTORATION PROGRAM
Goodfellow Air Force Base

Detailed information on these individuals is presented in Appendix B.

1.3 METHODOLOGY

The methodology utilized in the GAFB records search began in September 1984, with a review of past and current industrial operations conducted at the base. Information was obtained from available records, such as shop files and real property files, as well as interviews with past and current base employees from the various operating areas. Interviewees included current and past Air Force personnel and civilian employees. A list of interviewees by position and approximate years of service is presented in Appendix C.

The next step in the activity review was to determine the past management practices regarding the use, storage, treatment, and disposal of hazardous materials from the various operations on the base. Included in this part of the activities review was the identification of all known past disposal sites and other possible sources of contamination, such as spill areas.

A ground tour of the identified sites was then made by the ESE Project Team to gather site-specific information including: (1) visual evidence of environmental stress; (2) the presence of nearby drainage ditches or surface water bodies; and (3) visual inspection of these water bodies for any obvious signs of contamination or leachate migration.

Using the process shown in Figure 1.3-1, a decision was then made, based on all of the above information, regarding the potential for hazardous material contamination at any of the identified sites. If no potential existed, the site was deleted from further consideration. If potential for contamination was identified, the potential for migration of the contamination was assessed based on site-specific conditions. If there were no further environmental concerns, the site was deleted. If the potential for contaminant migration was considered significant, the site was evaluated and prioritized using the Hazard Assessment Rating Methodology (HARM). A discussion of the HARM system is presented in

Environmental Science and Engineering, Inc. (ESE) conducted the records search at Goodfellow Air Force Base (GAFB), with funds provided by the Air Training Command (ATC). This report contains a summary and evaluation of the information collected during Phase I of the IRP and recommendations for any necessary Phase II action.

The objective of Phase I was to identify the potential for environmental contamination from past waste disposal practices at GAFB, and to assess the potential for contaminant migration. Activities performed in the Phase I study included the following:

1. Review of site records;
2. Interviews with personnel familiar with past generation and disposal activities;
3. Inventory of wastes;
4. Determination of estimated quantities and locations of current and past hazardous waste treatment, storage and disposal;
5. Definition of the environmental setting at the base;
6. Review of past disposal practices and methods;
7. Performance of field inspections;
8. Gathering of pertinent information from federal, state, and local agencies;
9. Assessment of potential for contaminant migration; and
10. Development of conclusions and recommendations for follow-on action.

ESE performed the onsite portion of the records search during September 1984. The following team of professionals was involved:

- Bruce N. McMaster, Ph.D., Senior Chemist and Project Manager, 16 years of professional experience.
- William G. Fraser, P.E., Environmental Engineer and Team Leader, 9 years of professional experience.
- Keith C. Govro, Ecologist, 9 years of professional experience.
- David H. Stephens, Geologist, 8 years of professional experience.

1.0 INTRODUCTION

1.1 BACKGROUND

Due to its primary mission, the U.S. Air Force (USAF) has long been engaged in operations dealing with toxic and hazardous materials. Federal, state, and local governments have developed strict regulations to require that disposers identify the locations and contents of disposal sites and take action to eliminate the hazards in an environmentally responsible manner. The primary Federal legislation governing disposal of hazardous waste is the Resource Conservation and Recover Act (RCRA) of 1976, as amended. Under Sec. 6003 of the Act, Federal Agencies are directed to assist the U.S. Environmental Protection Agency (EPA) and under Sec. 3012, state agencies are required to inventory past disposal sites and make the information available to the requesting agencies. To assure compliance with these hazardous waste regulations, the Department of Defense (DOD) developed the Installation Restoration Program (IRP). The current DOD IRP policy is contained in Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, dated December 11, 1981, and implemented by USAF message, dated January 21, 1982. DEQPPM 81-5 reissued and amplified all previous directives and memoranda on the IRP. DOD policy is to identify and fully evaluate suspected problems associated with past hazardous contamination and to control hazards to health and welfare that resulted from these past operations. The IRP will be the basis for response action on USAF installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as clarified by Executive Order 12316, and 40 CFR 300 Subpart F (National Oil and Hazardous Substances Contingency Plan). CERCLA is the primary legislation governing remedial action at past hazardous waste disposal sites.

1.2 PURPOSE, AUTHORITY, AND SCOPE OF THE ASSESSMENT

The IRP has been developed as a four-phase program, as follows:

- Phase I - Initial Assessment/Records Search
- Phase II - Confirmation and Quantification
- Phase III - Technology Base Development
- Phase IV - Operations/Remedial Actions

Table ES-2. Summary of Recommended Monitoring for GAFB Phase II Investigations

Site	HARM Score	Recommended Sampling	Recommended Analysis
South Landfill	58	Install four wells around known fill area, Three on north side one of south so as to establish gradient. Screen as necessary. Sample uppermost water bearing zone and drinking supplies considered at risk.	Total petroleum hydrocarbons, halogenated and nonhalogenated solvents, metals, PCBs, pesticides.
Drum Storage Area	42	Composite soil samples from upper six feet and wells if significant contamination is found.	Total petroleum hydrocarbons.
Southeast Landfill	35	Install four wells around site to establish ground water gradient. Adjust program to fit closure requirements.	Total petroleum hydrocarbons, halogenated and nonhalogenated solvents, metals, PCBs, pesticides.
Fuel Storage Area	4	None	NA

Source: ESE, 1984.

Fuel Storage Area

During the period of aircraft operations at GAFB, this area served as the main fuel storage site. It contained nine 25,000 gal underground (UG) tanks and dispensing facilities for filling trucks. Some evidence of possible leakage was reported when the tanks were excavated in 1976. Whether the tank leaked prior to the removal operation or the reported leakage resulted from the excavation itself could not be determined. Contaminated soil was reported removed by the salvage contractor who removed the tanks. The HARM score for this site is 4.

RECOMMENDATIONS

Table ES-2 summarizes recommendations for Phase II investigations at GAFB.

Table ES-1. Summary of HARM Scores

Rank	Site	Receptors	Waste Characteristics	Pathways	Waste Management Factor	Total
1	South Landfill	68	80	26	1.0	58
2	Drum Storage	68	32	33	0.95	42
3	Southeast Landfill	68	16	26	0.95	35
4.	Fuel Storage Area	65	24	33	0.10	4

Source: ESE, 1984.

Each of the sites discussed was rated using the HARM. The HARM scores are summarized in Table ES-1. The process of rating potential hazards using the HARM system is described in detail in Appendix D. Basically the method uses numerical ratings for a number of discrete variables to calculate subscores for three categories. These categories represent the risk of human exposure (Receptors), the nature and quantity of waste (Waste Characteristics), and the potential migration routes (Pathways).

CONCLUSIONS

South Landfill

This site was operated as a general purpose trench and fill landfill from 1950 to 1970. It includes an area used as a fire training pit from 1953 to 1958. Little waste segregation was practiced during the period of operation, and no restrictions were placed on materials landfilled. Contents include industrial waste and containerized liquids. Soil permeability is slow to moderately slow. Ground water occurs at depths of 30 to 60 ft. The potential exists for contamination and/or migration involving solvents, fuels and oils. The HARM Score for this site is 58.

Drum Storage Area

This site was used to store several hundred drums in the early 1950's. Photographic evidence of extensive surface spillage exists, but little else is known about the site. The area was regraded in approximately 1953. Potential exists for residual POL contamination in soils. Soil permeability is 0.06 to 2.0 inches per hour (in/hr), and depths to water are 30 to 60 ft. The HARM Score for this site is 42.

Southeast Landfill

Operated as a trench and fill landfill beginning in 1970, this site was closed in 1982. During this period, industrial operations at GAFB were very limited. Landfill contents may include small containers of solvent, fuels, and oils. Soil permeability is low, and ground water does not occur at less than 50 ft depths. Limited potential for contamination exists. The HARM Score for this site is 37.

Detachment 1, 6960th Electronic Security Wing - administers and operates the instructional programs for the Electronic Security Command.

National Highway Tire Safety Agency - operates a tire safety testing activity on GAFB.

3.0 ENVIRONMENTAL SETTING

3.1 METEOROLOGY

The climate of the San Angelo area is classified as semi-arid with warm, dry weather predominating. Precipitation averages approximately 21-in/yr, with an average of about 18.5-in of rainfall and 2.5-in of snowfall. September is generally the wettest month, December the driest.

The average annual temperature is 65 degrees Fahrenheit (°F). January is the coldest month with an average temperature of 47°F. July is the warmest month, with an average temperature of 85°F. The area experiences an average of 232 frost-free days. Winds average 11 mph on an annual basis. Winds generally come from the south-southwest sectors.

3.2 GEOGRAPHY

3.2.1 PHYSIOGRAPHY

GAFB lies just off the northeastern edge of the Edwards Plateau, within the rolling plains physiographic province (Figure 3.2-1). The topography of GAFB can be characterized as level to very gently rolling. The range of surface elevations is relatively small and no significant relief occurs on the base (Figure 3.2-2).

Elevations range from 1,840 ft in the northern portion of the site to 1,880 ft in the southern portion of the base. The airfield area which comprises a large portion of the site is especially level due in-part to airfield construction and maintenance. The cantonment area is only slightly more rolling in topography.

3.2.2 SURFACE HYDROLOGY

The GAFB region lies entirely within the Concho River Basin. The South Concho River runs generally north-northeast approximately 1 mile west of the base. The confluence of the North and South Concho Rivers lies approximately 1 mile north of GAFB. From here the rivers run generally east approximately 40 miles to its confluence with the Colorado River. Both the branches of the river are impounded above San Angelo, the North

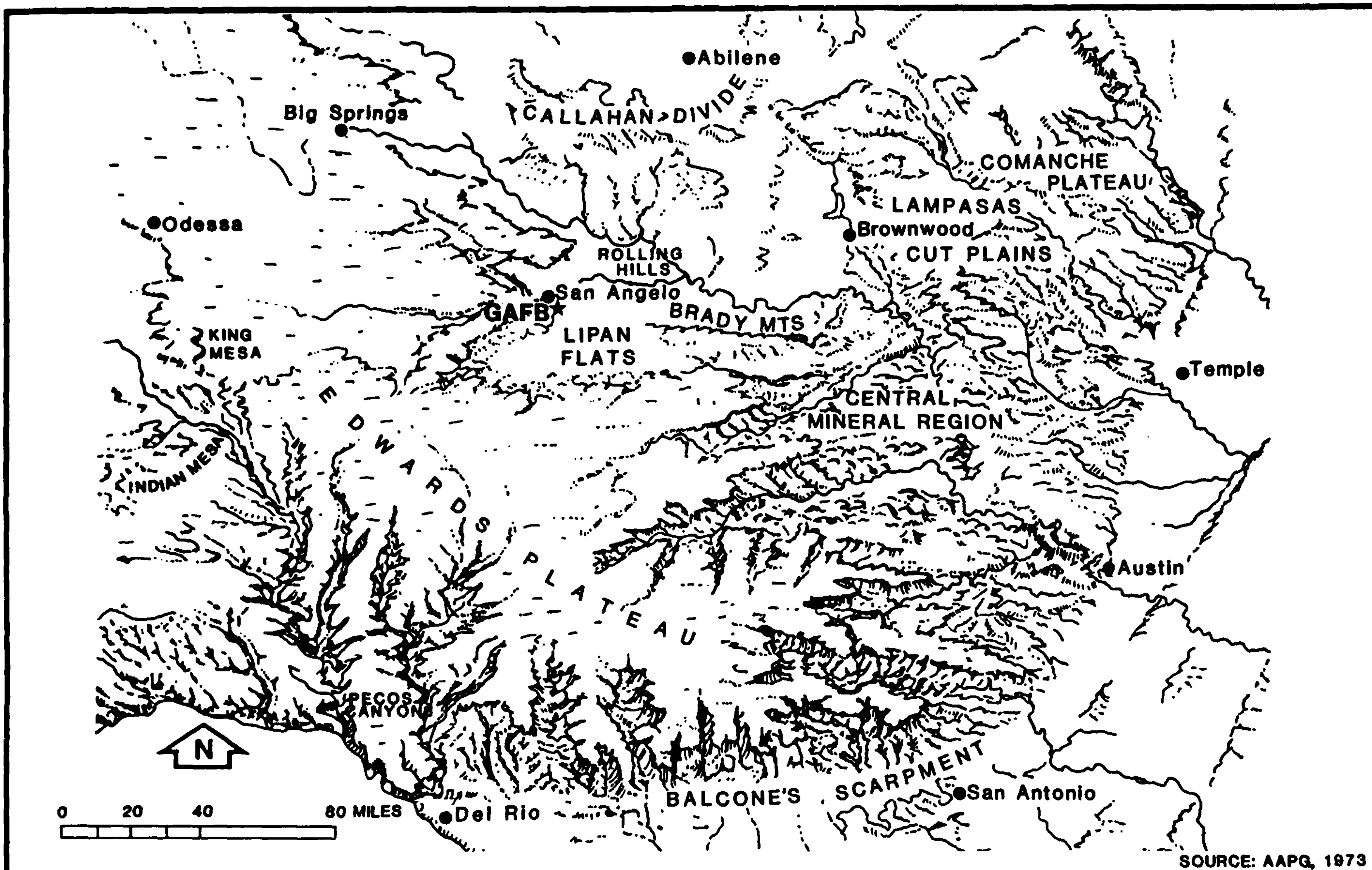
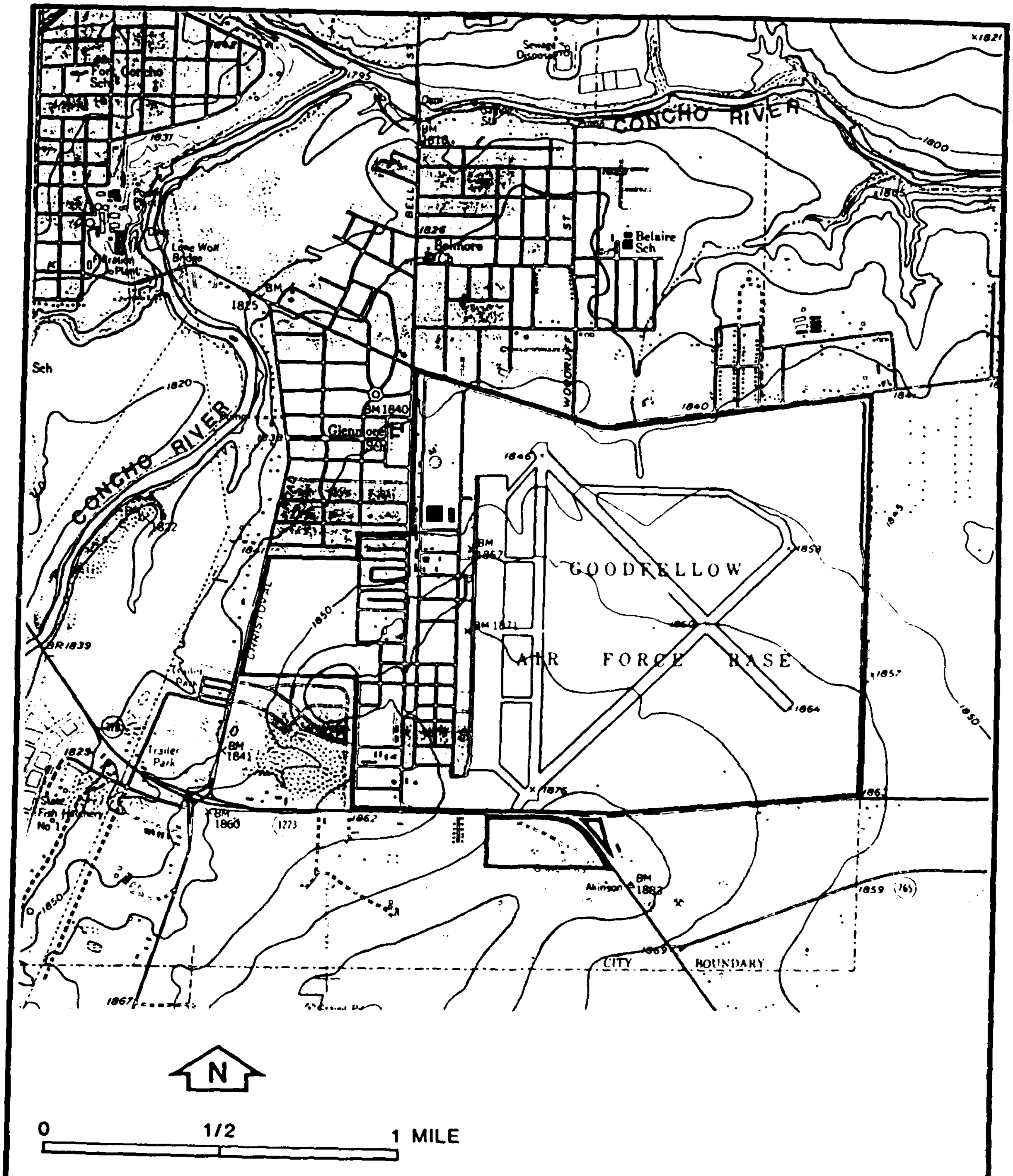


Figure 3.2-1
PHYSIOGRAPHIC MAP OF SOUTHWEST TEXAS

INSTALLATION RESTORATION PROGRAM
Goodfellow Air Force Base



SOURCE: USGS, 1978

Figure 3.2-2 TOPOGRAPHIC MAP OF GAFB, SAN ANGELO, TEXAS	INSTALLATION RESTORATION PROGRAM Goodfellow Air Force Base

Concho forming O.C. Fisher Lake, and the South Concho forming Lake Nasworthy and Twin Buttes Reservoir.

No well-developed natural surface drainage features are within GAFB. Drainage is generally accomplished by a system of stormwater drainage ditches receiving surface runoff from the surrounding land area (Figure 3.2-3).

3.3 GEOLOGY

3.3.1 GEOLOGIC SETTING

GAFB is located within the geologic province of the Eastern Shelf (Figure 3.3-1), a constructional platform developed on the eastern flank of the Midland Basin during Late Pennsylvanian-Early Permian time (Figure 3.3-2). The feature was formed on the older Concho Platform and consists of rocks formed in depositional environments associated with the formation of a sedimentary-tectonic feature between the craton and a more rapidly subsiding, more mobile basin of sedimentation (Figure 3.3-3). Contemporaneous upbuilding by fluvial, deltaic and shelf-edge bank deposition and outbuilding by slope-fan deposition caused the progradation of the shelf from sediment sources of the Ouachita fold belt and uplifted Fort Worth Basin westward into the Midland Basin (Galloway and Brown, 1972). During its construction the Eastern Shelf represented a structurally stable platform and was affected only by regional tilting and minor faulting (Wermund and Jenkins, 1969).

Rocks of Precambrian Age are the oldest rocks in the area. Tectonic activity characterized the era and resulted in general uplift of the area northeast, east and southeast of the present day Eastern Shelf. Accomplishing metamorphism resulted in the alteration of pre-existing volcanic and sedimentary rocks to granites, schists, and gneisses.

Marine conditions dominated throughout the Cambrian. Differential subsidence of the sea bottom resulted in sea level flucuation and a variety of depositional environments. Rocks of the Riley Formation and Wilberns Formation reflect these changes in their mixed terrigenous-carbonate lithologies.

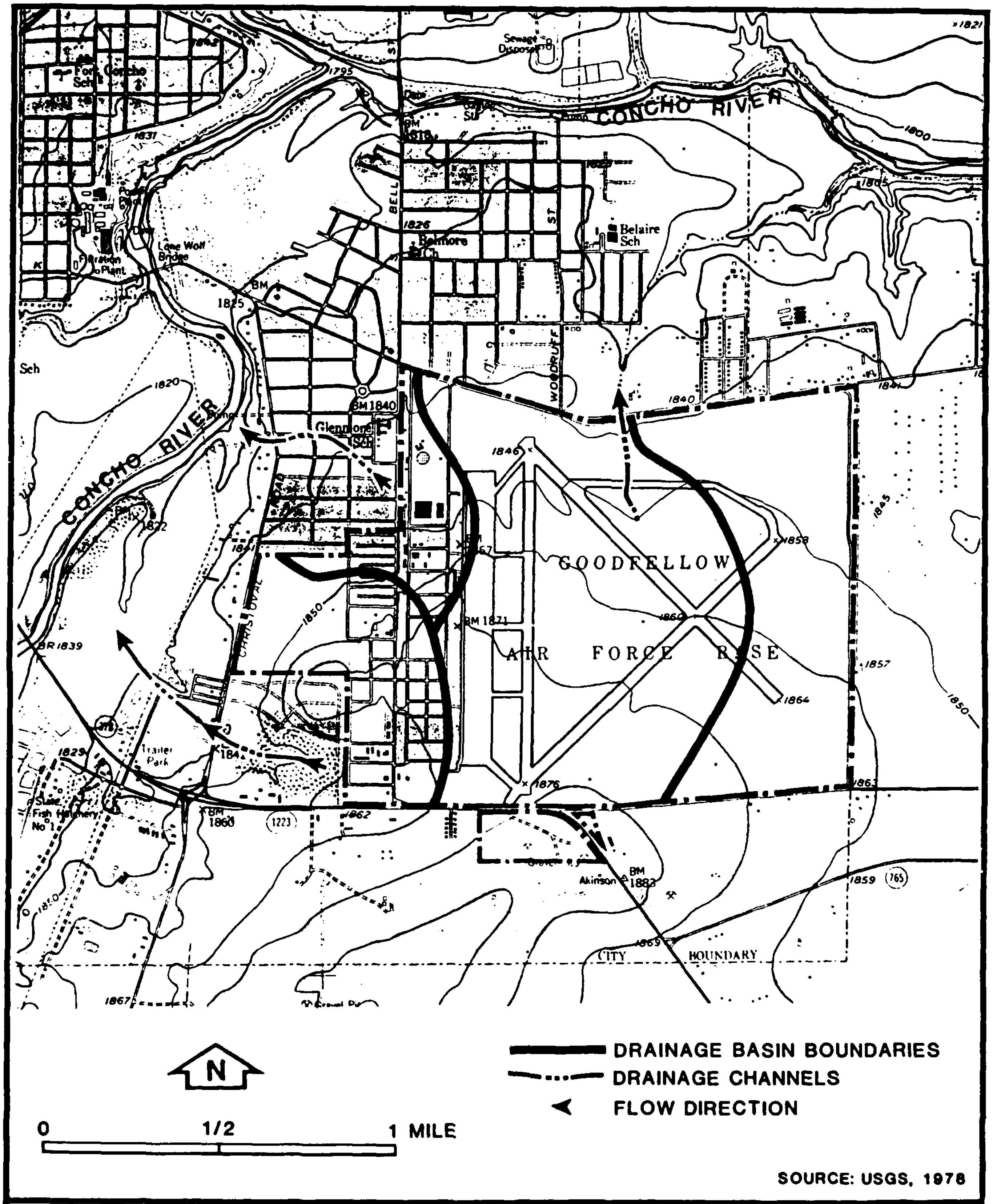


Figure 3.2-3 SURFACE WATER DRAINAGE	INSTALLATION RESTORATION PROGRAM Goodfellow Air Force Base

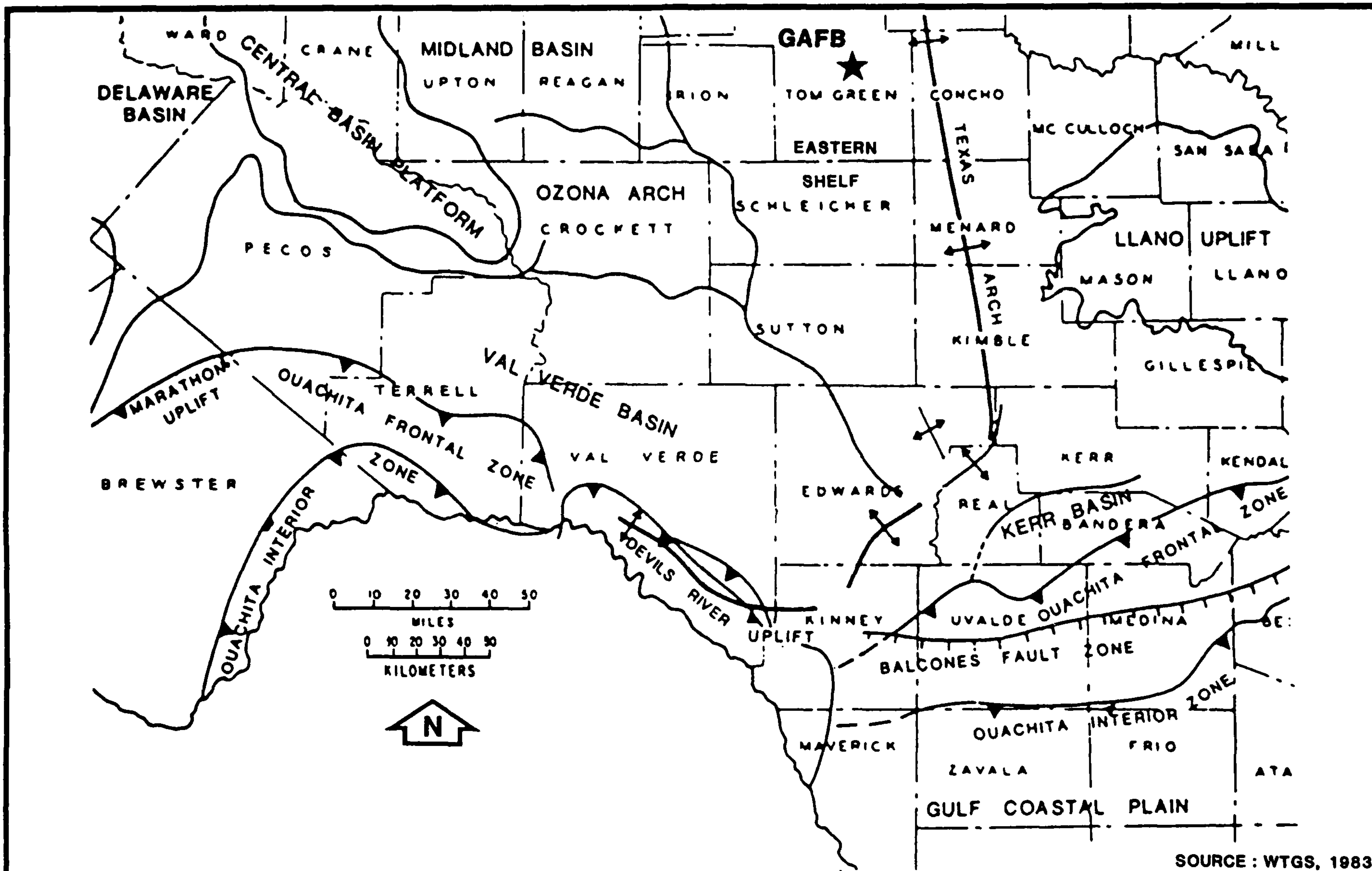


Figure 3.3-1
MAJOR STRUCTURAL ELEMENTS
OF SOUTHWEST TEXAS

INSTALLATION
RESTORATION PROGRAM
Goodfellow Air Force Base

ERA	SYSTEM and PERIOD	SERIES and EPOCH	STAGE and AGE: North American	STAGE and AGE: Europe	ABSOLUTE AGE
Cenozoic	Quaternary	Recent			(Duration in years[1] Approximately the last 10,000 years.
		Pleistocene	In glaciated regions (Glacial stages underlined)		
			Wisconsin Wurm		10,000 ± to 35,000 years ago
			Sangamon Illinoisan Yarmouth Kansan Aftonian Nebraskan	Wurm-Riss Riss Riss-Mindel Mindel Mindel—Gunz Gunz	
	Tertiary	Pliocene	(Atlantic and Gulf Coast)[6] Upper	(Europe) Astian	(Million of years ago)
			Lower	Plaisanclan	
		Miocene	Upper	Sahelian: Pontian Samatian	21
			Middle	Tortonian Helvetian	
			Lower	Burdigalian Aquitanian	
		Oligocene	Upper Middle Lower	Chattian Rupelian Tongrian	
		Eocene	Jackson	Ludian Bartonian	39
			Claiborne	Auversian Lutetian	
			Wilcox	Cuisain Ypresian	
		Paleocene	Midway	Thanetian Montian	60
Mesozoic	Cretaceous	Upper (Late)	No accepted classification for North America generally.	Maestrichtian Campanian Santonian Coniacian Turonian Cenomanian	70 70 90
		Lower (Early)	These European names commonly used in North America also	Albian Aptian Hauterivian Valanginian Berriasian	
	Jurassic	Upper (Late)		Purbeckian Portlandian Kimeridgian Oxfordian	140
		Middle (Middle)		Callovian Bathonian Bajocian	
		Lower (Early)		Toarcian Pliensbachian Sinemurian Hettangian	
	Triassic	Upper (Late) Middle (Middle)		Rhaetian Norian Carnian Ladinian Anisian	
		Lower (Early)		Scythian	

SOURCE: AMERICAN GEOLOGICAL INSTITUTE, 1965

Figure 3.3-2
GEOLOGIC TIME SCALE
(PAGE 1 OF 2)

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ERA	SYSTEM and PERIOD	VARIED SUBDIVISIONS			ABSOLUTE AGE (Millions of years ago)
		SERIES & EPOCH	STAGE and AGE		
Paleozoic	Permian	(West Texas)	Not established in North America	(Russia)	
		Ochoa		Kazanian	220
		Guadalupe		Kungurian	
		Leonard		Artinskian	
		Wolfcamp		Sakmarian	
	Carboniferous Systems – Pennsylvanian	(Central North America)		(Europe)	
		Virgil	Not established	Stephanian	
		Missouri		Westphalian	
		Des Moines		Upper	
		Atoka		Namurian	
		Morrow			
	Carboniferous Systems – Mississippian	Chester	Not established	Lower	
		Meramec		Namurian	
		Osage		Visean	
		Kinderhook		Tournaisian	
		SERIES & EPOCH		STAGE and AGE	
	Devonian	(Eastern United States)		(Europe)	
		Bradfordian	Conewango	Famennian	
		Chautauquan	Cassadaga		
			Chemung		
		Senecan	Finger Lakes	Frasnian	270
			Taghanic		
		Erian	Tioghnioga	Givetian	
			Cazenovia	Eifelian	
			Onesquethaw		
		Ulsterian	Deerpark	Coblenzian	
			Helderberg	Gedinnian	
		SERIES & EPOCH		STAGE and AGE	
	Silurian	(North America)	(Britian)	Not established	
		Cayugan	Downtonian		
		Niagaran	Ludlovian		
		Albion	Wenlockian		
			Valentian		
		SERIES & EPOCH	STAGE and AGE	SERIES and EPOCH	
	Ordovician	(North American)		(Britain)	
		Cincinnatian	Gamachian	Ashgillian	375
			Richmondian		
			Maysvillian		
			Edenian	Caradocian	
		Champlainian	Mohawkian	Llandeilian	
			Chazyan	Skiddavian	
		Canadian	Not established	Tremadocian	
	Cambrian	Croixan	Not established	Not established	440
		Albertan			
		Waucaban			470
Precambrian	(No bases for worldwide divisions)	Latest Precambrian (?) (Wichita Mountains, Oklahoma)			550
		(Minnesota Scale)			
		Keweenawan Group			1100
		Pre-Keweenawan orogeny			
		Animikie Group			1700
		Algoman orogeny			2300
		Knife Lake Group			
		"Laurentian" orogeny			2700
		Keewatin Group			
		Oldest radiogenic date reported (Southern Rhodesia)			3310

SOURCE: AMERICAN GEOLOGICAL INSTITUTE, 1965

Figure 3.3-2
GEOLOGIC TIME SCALE
(PAGE 2 OF 2)

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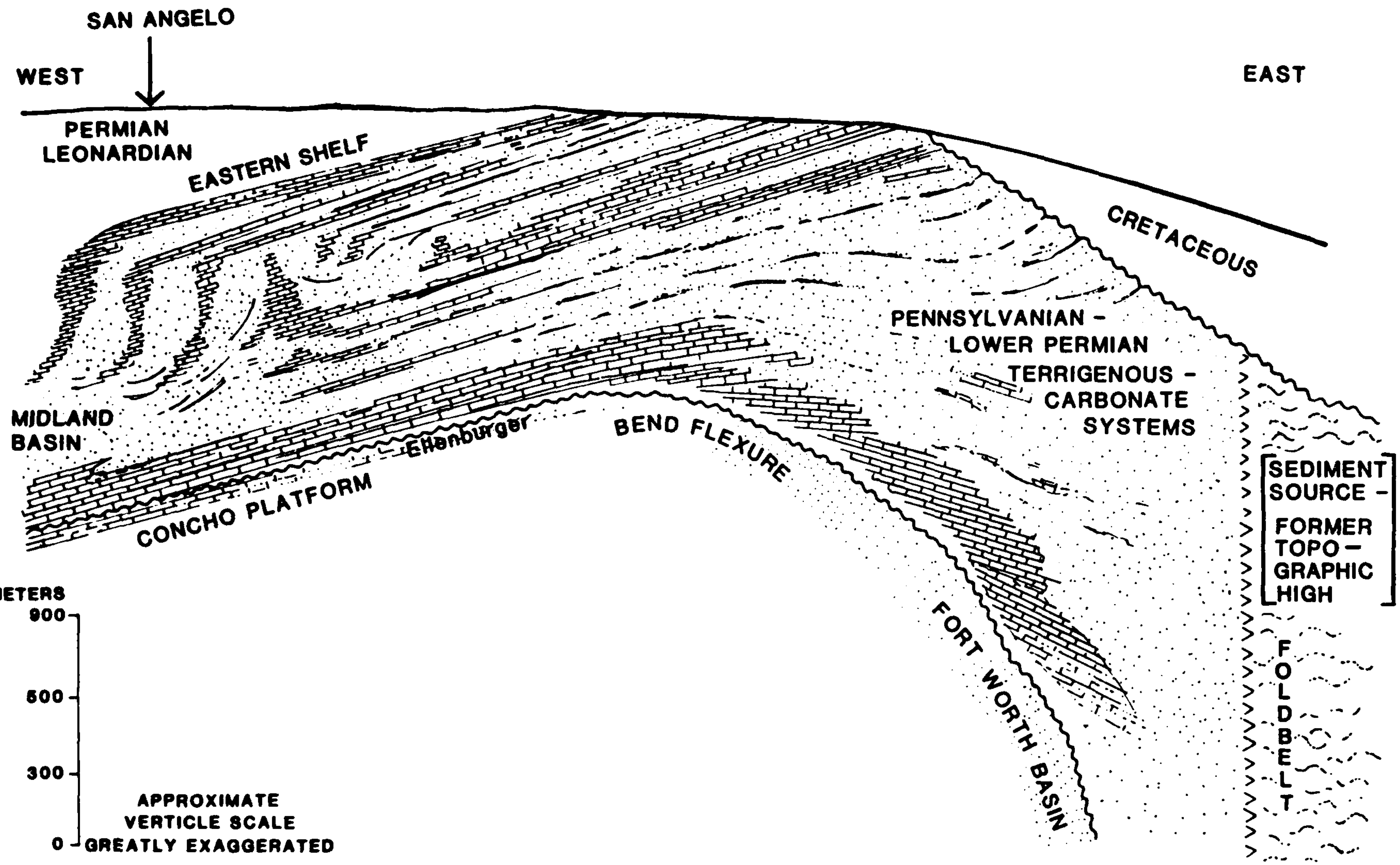

SOURCE: MODIFIED FROM USGS,1979

Figure 3.3-3
CROSS SECTION -EASTERN SHELF, SAN ANGELO,TEXAS

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During Early Ordovician time, the extensive epicontinental sea covered the area and resulted in deposition of the Ellenburger Group, a sequence of crystalline limestones and dolomites with chert. Uplift and erosion in Middle Ordovician lasted until Late Ordovician when subsidence of the land surface caused renewed sedimentation. Rocks deposited during this time were soon removed due to renewed uplift and erosion at the close of the Ordovician.

At the end of Ordovician time the region was tilted to the east causing a prolonged period of emergence and non-deposition. The area remained structurally and topographically high and relatively stable until Pennsylvanian when tectonic activity was renewed and the structural and depositional framework for the Eastern Shelf formed. Pennsylvanian strata represent a series of time transgressive terrigeneous-carbonate facies formed under characteristic shelf depositional environments. Sediment source was from the uplifted areas north, south and east of the area. Stratigraphically the record includes rocks of the Atokan Series, the Strawn, Canyon, and Cisco Groups.

Little regional earth movement was experienced during Early Permian, except for the continued tilting of the landmass toward the Midland Basin. This movement caused the shoreline to migrate westward. Relatively unstable near-shore conditions existed along the eastern part of the platform area, while reef masses were building on the Eastern shelf.

Some reef building continued into Middle Permian time on the Eastern shelf; however, the predominant sediments were gypsum, anhydrite, and dolomitic limestone. During the middle Permian, sediments continued to thicken westward toward the basin area.

Conditions favorable to the deposition of evaporites continued throughout the Late Permian time with salt, anhydrite, and shale (red beds) being deposited in the basin area. To the east, along the western edge of the Eastern shelf, evaporites gave way to sands and shales with minor amounts of anhydrite.

In the GAFB area Permian strata are represented by rocks of Wolfcampian Age, and the Clear Fork Group and Peuse River Group of Leonarian Age.

As the Permian sea retreated from the Midland Basin, erosion and local folding followed, thus, separating the Permian Formations from subsequent sediments by an extensive regional unconformity. Although erosion was widespread, the amount of Permian material removed is thought not to have been great.

In Late Triassic time, considerable uplift to the east initiated deposition of sands, conglomerates, and shales west of the area. The Triassic sediments were deposited on the eroded Permian surface.

The Triassic is represented in the GAFB area by rocks of the Dockum Group.

Triassic and Paleozoic rocks were subjected to erosion during the Jurassic and Early Cretaceous, forming a nearly flat or broadly undulating plain named the Wichita paleoplain. It was over this eroded surface that the last epicontinental sea advanced northward from the Gulf across Texas.

A major structural high dominated deposition during the Cretaceous in the GAFB area. The high consisted of Permian rocks and restricted Cretaceous sedimentation. As the Cretaceous sea transgressed and regressed around the high, deposition of Commanche Series rocks occurred. These include the Trinity Group, Edwards Group, and Washita Division strata.

With the region above sea level, erosion attacked the thick sections of Cretaceous rocks, depositing sediments along the streams which transverse the area. The deposits are in the form of terraces and flood-plain deposits that are Tertiary and Quaternary in age.

Tertiary fluviatile deposits are represented in the form of the Ogallala Formation. Quarternary alluvium of Pleistocene Age is referred to

locally as the Leona Formation. Recent stream deposits complete the sequence in the GAFB area.

GAFB lies on a bedrock surface formed on the Choza Formation of the Clear Fork Group. Alluvium of the Leona Formation mantles the surface and obscures the bedrock. Depth to bedrock is from 5 to 20+ ft. Rocks dip to the west-northwest into the Midland Basin. The stratigraphic section present in the area of GAFB is detailed in Figure 3.3-4 and Table 3.3-1.

3.3.2 SOILS

Landscapes at GAFB are dominated by soils of the Kimbrough-Merta-Angelo association (Figure 3.3-5). In general, the association is characterized by very shallow, shallow and deep, nearly level to sloping and undulating, clayey and calcareous soils of outwash plains. Distribution of the association is in broad valleys of tributaries of the Concho River. The association is predominantly in rangeland. Soils exhibit permeabilities ranging from 0.06 to 2.0 in/hr with slow to moderate surface runoff. Minor soils in the association are Tulia, Olton, Estacado, Rotan, Slaughter, and Owens soils. Soil series present at GAFB are described as follows (USSCS, 1976):

Kimbrough Series: The Kimbrough series consists of gently sloping to sloping undulating soils on outwash plains.

In representative profile the surface layer is grayish-brown gravelly loam about 9-in thick. The next layer is white, indurated caliche about 6-in thick. Below the indurated cliche is pink caliche that extends to a depth of 72-in. The pink caliche is underlain by pinkish-white loam that extends to a depth of 90-in.

Kimbrough soils are well drained, and surface runoff is medium. Permeability is 0.6 to 2.0 in/hr. Available water capacity is low.

These soils are not suited to crops. They are mostly used as range and wildlife habitat.

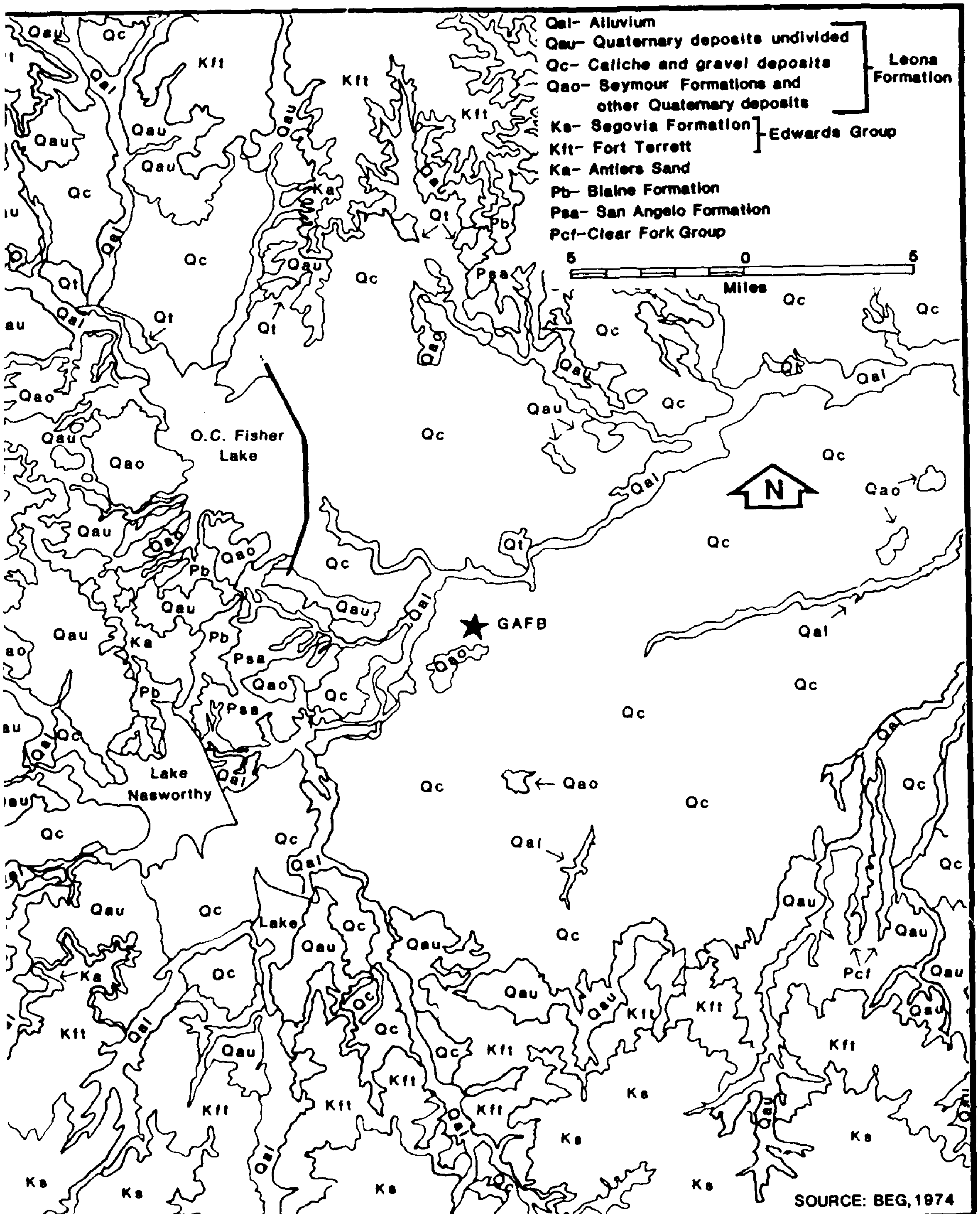

Figure 3.3-4
GEOLOGIC MAP-SAN ANGELO AREA

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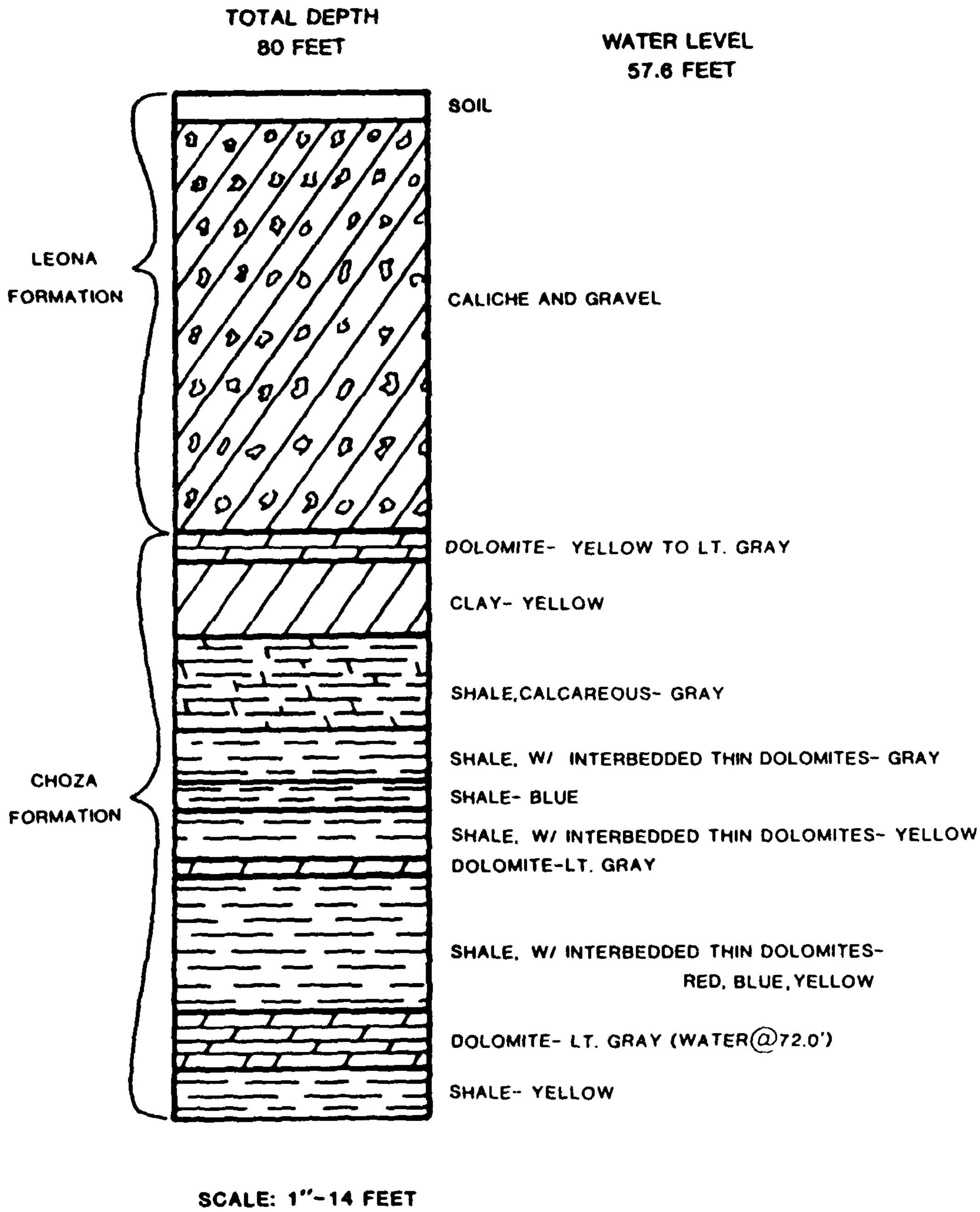
Table 3.4-1. Water Quality Data, O. C. Fisher Lake at San Angelo, Texas. Water Year: October 1981 to September 1982. (Page 1 of 3)

DATE	TIME	SAMPLING DEPTH (FEET)	SPECIFIC CONDUCTANCE (UMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	TRANSPARENCY (SECCHI DISK) (M)	OXYGEN, DISSOLVED (MG/L)	OXYGEN, DISSOLVED (PERCENT SATURATION)	COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)
FEB										
11...	1242	1.00	599	8.1	7.0	1.00	11.2	97	K3	K7
11...	1243	1.70	--	--	--	--	--	--	--	--
11...	1244	10.0	599	8.2	7.0	--	11.1	96	--	--
11...	1246	20.0	598	8.2	6.5	--	11.0	94	--	--
11...	1248	30.0	598	8.2	6.5	--	10.9	93	--	--
11...	1250	33.0	597	8.2	6.5	--	10.6	91	--	--
APR										
28...	0926	1.00	656	8.1	17.0	.90	9.1	100	K2	K32
28...	0927	1.60	--	--	--	--	--	--	--	--
28...	0928	10.0	657	8.0	16.5	--	8.2	89	--	--
28...	0930	20.0	658	8.0	16.5	--	7.8	85	--	--
28...	0932	30.0	660	7.8	16.0	--	6.5	70	--	--
28...	0934	32.0	660	7.7	16.0	--	5.2	56	--	--
AUG										
17...	0820	1.00	650	7.8	28.0	1.10	7.8	107	K2	110
17...	0821	1.80	--	--	--	--	--	--	--	--
17...	0822	10.0	650	8.5	28.0	--	7.7	105	--	--
17...	0824	20.0	654	7.7	27.5	--	6.4	86	--	--
17...	0826	30.0	660	7.1	27.0	--	.9	12	--	--
17...	0828	33.0	659	7.1	27.0	--	1.0	13	--	--

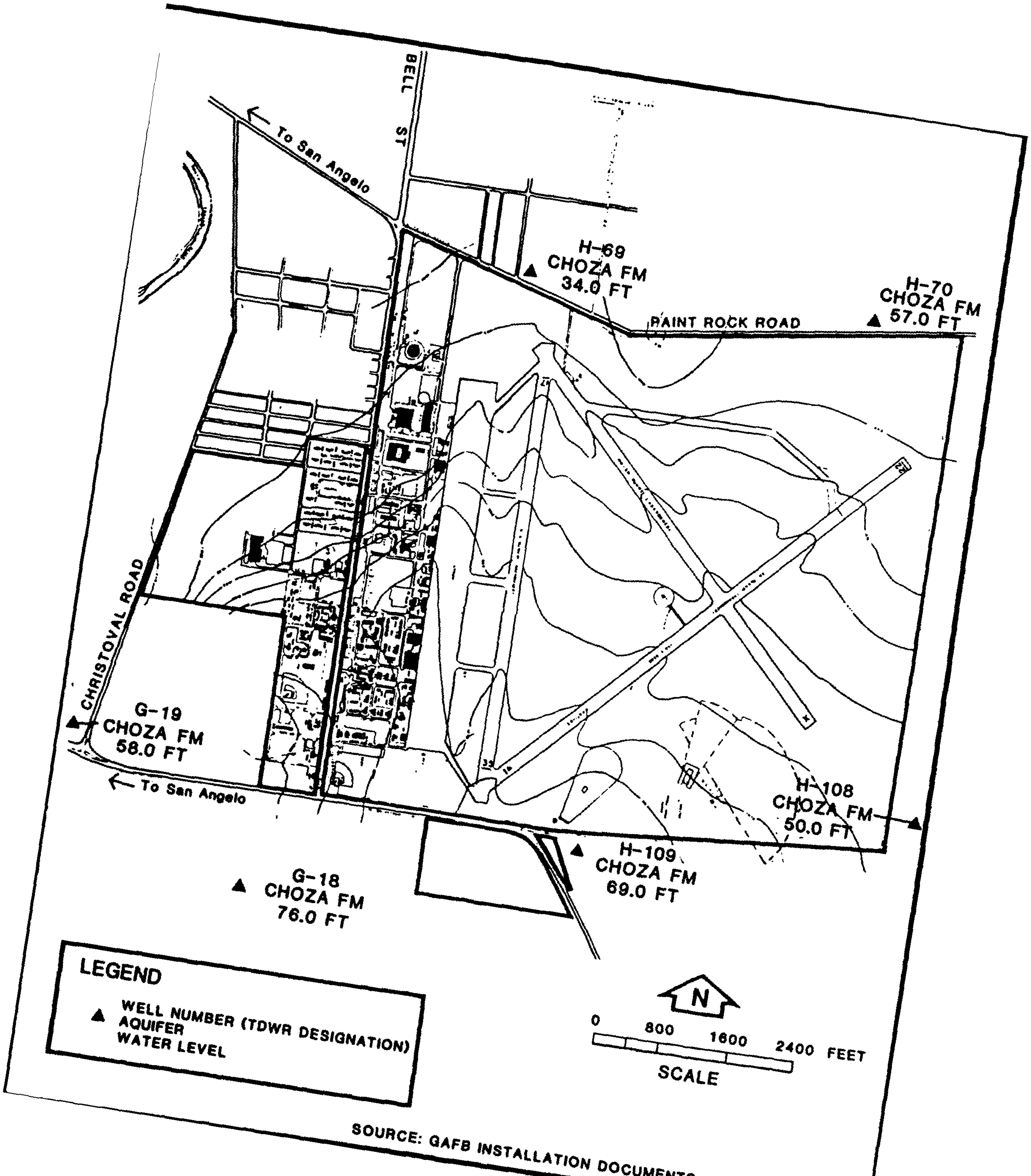
DATE	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)
FEB										
11...	220	55	50	22	37	1.2	12	160	40	87
11...	--	--	--	--	--	--	--	--	--	--
11...	--	--	--	--	--	--	--	--	--	--
11...	--	--	--	--	--	--	--	--	--	--
11...	--	--	--	--	--	--	--	--	--	--
11...	220	58	51	22	36	1.2	13	160	39	88
APR										
28...	240	79	56	24	37	1.1	13	160	40	98
28...	--	--	--	--	--	--	--	--	--	--
28...	--	--	--	--	--	--	--	--	--	--
28...	--	--	--	--	--	--	--	--	--	--
28...	--	--	--	--	--	--	--	--	--	--
28...	240	74	58	24	40	1.2	13	170	40	96
AUG										
17...	220	75	45	25	45	1.5	13	140	39	98
17...	--	--	--	--	--	--	--	--	--	--
17...	--	--	--	--	--	--	--	--	--	--
17...	--	--	--	--	--	--	--	--	--	--
17...	--	--	--	--	--	--	--	--	--	--
17...	220	70	47	25	44	1.4	13	150	39	97

DATE	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)	NITROGEN, NITRITE TOTAL (MG/L AS N)	NITROGEN, NO2+NO3 TOTAL (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	PHOSPHORUS, TOTAL (MG/L AS P)	IRON, DISSOLVED (UG/L AS FE)	MANGANESE, DISSOLVED (UG/L AS MN)
FEB									
11...	.2	7.0	351	--	<.10	1.10	.010	<10	<1
11...	--	--	--	--	--	--	--	--	--
11...	--	--	--	--	--	--	--	--	--
11...	--	--	--	--	<.10	.89	.020	50	10
11...	--	--	--	--	--	--	--	--	--
11...	--	7.5	353	--	<.10	1.10	.010	110	21
APR									
28...	.4	6.3	371	<.020	<.10	1.10	.050	13	<3
28...	--	--	--	--	--	--	--	--	--
28...	--	--	--	--	--	--	--	--	--
28...	--	--	--	<.020	<.10	.96	.040	20	<10
28...	--	--	--	--	--	--	--	--	--
28...	--	6.6	380	<.020	<.10	1.10	.060	20	12
AUG									
17...	.3	8.1	358	--	<.10	.90	<.010	9	<1
17...	--	--	--	--	--	--	--	--	--
17...	--	--	--	--	--	--	--	--	--
17...	--	--	--	--	<.10	1.00	.010	30	<10
17...	--	--	--	--	--	--	--	--	--
17...	--	9.5	365	--	<.10	1.80	.040	180	94



SOURCE: TDWR, 1954

Figure 3.3-9 **LITHOLOGIC LOG OF WATER WELL H-70**	**INSTALLATION RESTORATION PROGRAM** **Goodfellow Air Force Base**



SOURCE: GAFB INSTALLATION DOCUMENTS, 1984 & TDWR, 1954

semi-confined as the water column rose some 27 ft above the water-bearing unit. An examination of data regarding water wells in the proximity of GAFB (Figure 3.3-8 and Figure 3.3-9) further substantiates the presence of the aquifer in the area. Water level measurements from the wells indicate the water table to be at 34 ft to 76 ft below land surface.

3.4 WATER QUALITY

3.4.1 SURFACE WATER

Surface water plays an important role in the San Angelo area because ground water resources in the immediate area are neither abundant nor of good quality. San Angelo receives most of its water from O.C. Fisher Lake, (Table 3.4-1) Twin Buttes Reservoir (Table 3.4-2), and Lake Nasworthy (Table 3.4-3). In addition, E.V. Spence Reservoir, north of the town of Robert Lee, is used as a supplemental supply during periods of water shortages. GAFB is connected to the city's water distribution system.

The principal streams in the county are the Concho River and its main tributaries, the North Concho (Table 3.4-4), Middle Concho, and South Concho Rivers. The Concho River is formed by the confluence of these main tributaries in San Angelo. Several tributaries of the Middle Concho and the South Concho Rivers in the southwestern and southern parts of the county are fed by springs that flow from crevices in Cretaceous limestones. Tributary streams are generally dry during most of the year (Willis, 1954).

Any surface water on GAFB proper is in the form of stormwater runoff. Water quality of such a source is probably degraded due to various commercial and industrial practices at GAFB. Oil and grease, dust and dirt, litter, leaves, pesticides, herbicides, fertilizers and animal and bird droppings adversely affect the quality.

LOG OF BORING FOR WASTE DISPOSAL SITE								Sheet 2 of 2
DATE: September 13, 1977						BORING NO. 5		
PROJECT LOCATION: Goodfellow AFB, Tex.				TYPE: Wash Boring		LOCATION: See Plan		
DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION Continued from Sheet 1	CORE DRILLED	CORE RECOVERED	ELEVATION	DEPTH SCALE
50				Tan and Gray Shale with Scattered Gravel ▼ W.S. 9-13-77 Same Level 9-16-77				
55 60 65 70				Red Shale				
75				—— 100% water loss Conglomerate				
80 85				Gray Shale				
				Total Depth of Boring = 85.0 Feet Note: The boring was advanced the entire depth using drilling fluid. The hole was bailed of drilling fluid and water rose to the 47.7 foot level. After approximately 72 hours, the water level remained at the 47.7 foot depth.				

SOURCE: TRINITY ENGINEERING TEST CORP., 1977

Figure 3.3-7
LITHOLOGIC LOG OF SOIL BOREHOLE
(PAGE 2 OF 2)

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LOG OF BORING
FOR
WASTE DISPOSAL SITE

Sheet 1 of 2

DATE: September 13, 1977
PROJECT LOCATION: Goodfellow AFB, Tex. TYPE: Wash Boring
BORING NO. 5
LOCATION: See Plan

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED	CORE RECOVERED	ELEVATION	DEPTH SCALE
				Brown Clay with Caliche Particles				
5, 10, 15, 20				Tan Caliche and Gravel				
25				Tan Dolomite				
				Tan Clayey Sand				
30, 35				Tan Clayey Gravel				
40				Tan and Gray Shale with Scattered Gravel				
45				Continued on Sheet 2				

SOURCE: TRINITY ENGINEERING TEST CORP., 1977

Figure 3.3-7
LITHOLOGIC LOG OF SOIL BOREHOLE
(PAGE 1 OF 2)

INSTALLATION
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Goodfellow Air Force Base

Table 3.3-3. Formations - Water Bearing Characteristics

System	Series or Group	Formation	Topographic Expression	Water-bearing Characteristics
Quaternary	Recent-Pleistocene	Alluvium (Leona Formation)	Terraces and sand and gravel bars in creek and river channels. Extensive flat terrace	Yields potable water in sufficient quantities for irrigation where there are suitabl saturated thick.esses of permeable materia..
Cretaceous	Washita Division			
Commanche Series	Fredericksburg Division	Edwards Group	Caps of highest hills and divides Steep slopes of hills. Gentle slopes of hills.	Yields potable water in wells in the hilly area in the southern part of the county. Source of water for major springs in the hilly area.
	Trinity Group	Antlers Formation	Lower slopes of hills generally covered by alluvium and slump from overlying rocks	Yields small amounts of potable water in the southwest, northwest, and north-central parts of the county.
Permian	Pease River Group	Blaine Gypsum	Weathered slopes in many places covered by alluvium and slump from overlying Cretaceous rocks.	Yields small amounts of highly mineralized water.
		San Angelo Sandstone	Low hills and slopes of hills in north-central part of the county.	Yields small amounts of highly mineralized water.
	Clear Fork Group	Choza Formation	Plain covered by Leona formation south of the Concho River. Low hills north of the Concho River.	Yields small amounts of highly mineralized water from layers of dolomitic limestone. Source of water for a few small irrigation wells.
		Bullwagon dol Member	ow ridge trending orth-south across Lipan Flat.	Yields potable water in amounts from 100 to 1,000 gpm for irrigation in a narrow area west of its outcrop.
		Vale Formation	Plain covered by soil and alluvium.	No water supply.
		Standpipe limestone Member	Plain generally covered by soil and alluvium.	Yields small amounts of potable water near its outcrop.
		Arroyo Formation	Plain covered by soil and alluvium.	Yields small amounts of moderately to highly mineralized water from layers of limestone.
Cambrian		Riley Formation Hickory Sandstone	Subsurface	Moderate to large amounts of fresh to slightly saline water.

Source: TDWR, 1954 and 1979.

recovered from only five boreholes, all in the southeast portion of the base. Results indicate relatively impervious to very low permeability soils (<0.6 in/hr) present there.

3.3.3 GEOHYDROLOGY

Major water-bearing units in the area of GAFB are various carbonate and clastic strata in rock of Permian Age, the weakly lithified gravels and conglomerates of Pleistoene Age and the sediments of recent stream deposits. Where erosion has not removed the section, water supplies are obtained from limestones and sandstones of the Cretaceous rocks of Early Paleozoic Age also yield water to wells in the area. Principal aquifers are the Permian Bullwagon Dolomite Member of the Vale Formation, the Edwards Group and Trinity Group of Cretaceous age and the Pleistocene Leona Formation (Table 3.3-3).

Precipitation is the source of ground water recharge in the area of GAFB. Recharge to the major aquifers occurs mainly through direct infiltration of precipitation on the land surface and by streamflow across outcrop areas. The intergranulatar pore space of the sandstones and unconsolidated alluvium and the joints, crevices and solution openings of the carbonates represent a network which readily permits infiltration of ground water.

Discharge of ground water to the surface is accomplished through springs and seeps, by evapotranspiration where the water table is near the surface, and by wells. Ground water movement in the area of GAFB is generally towards the Concho River and its tributaries. Local variation may occur due to the pumping of wells for irrigation and livestock purposes.

Information regarding ground water supply and occurrance at GAFB is limited as no water wells have ever been completed on the base. One borehole completed in the southeast corner of the base did encounter water (Figure 3.3-7) and indicates a water-bearing zone at 75 ft below the surface. The bore appears to have produced water from a conglomeratic sequence in the Permian Choza Formation. The aquifer is

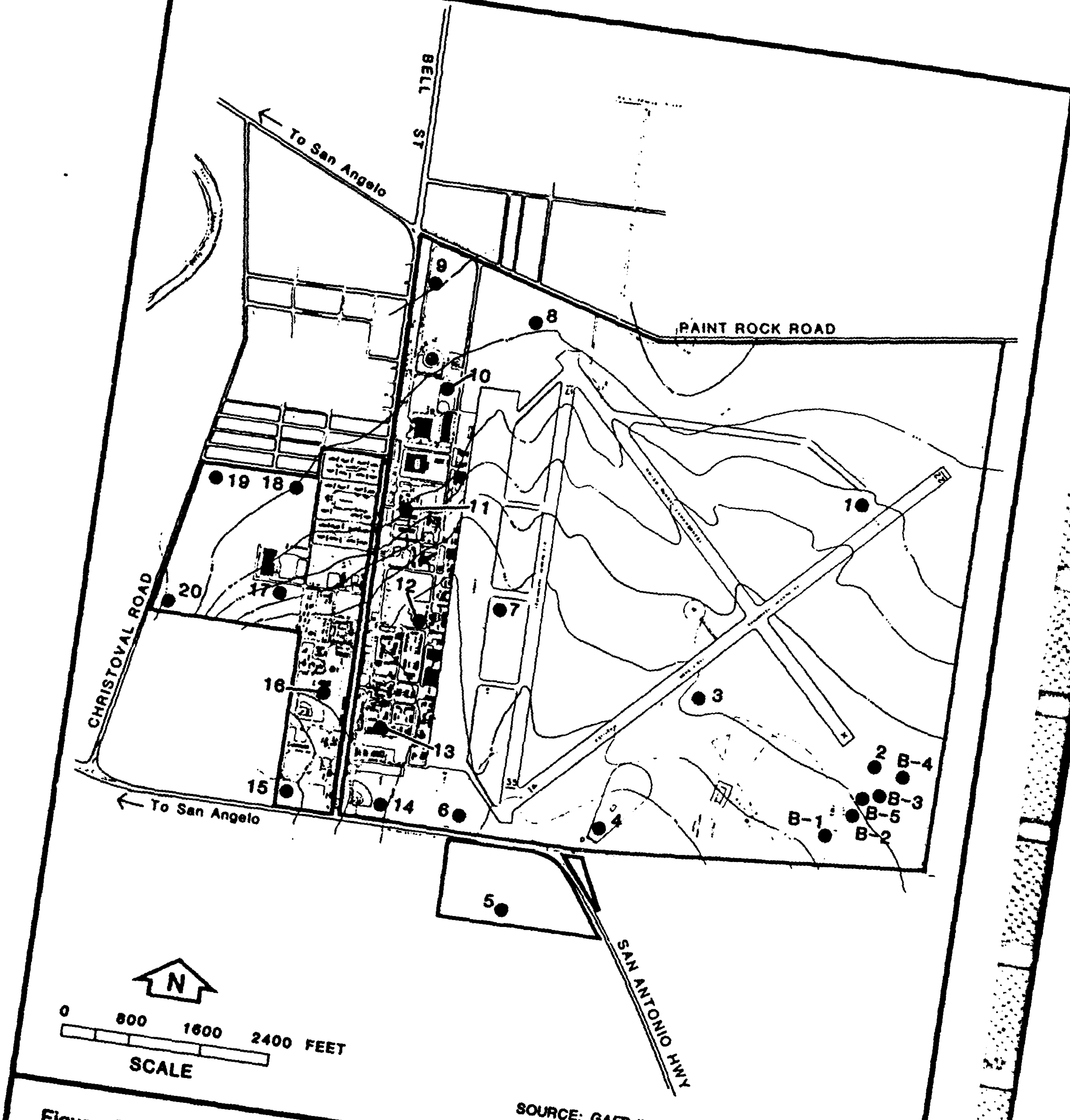

Figure 3.3-6
LOCATION MAP- SOIL BORINGS

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Table 3.3-2. Soil Characteristics and Properties

	Permeability [1] (in/hr)	Available Water Capacity[2] (in/in)	pH[3]	Hydrologic Unit [4]
Angelo	0.20-2.00	0.10-0.15	7.9-8.4	C
Kimbrough	0.63-2.00	0.10-0.15	7.9-8.4	D
Mereta	0.20-0.63	0.15-0.20	7.9-8.4	C

1 - Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.6 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to 2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

2 - Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soils water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

	Inches
Very Low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

3 - pH Value. A numerical designation of acidity and alkalinity in soil.

4 - Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered, but are separate factors in predicting runoff. Soils are assigned to four groups. In Group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sand or gravelly. In Group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artifically drained and part is undrained.

Source: USSCS, 1976.

Mereta Series: The Mereta series consists of nearly level to gently sloping soils on outwash plains.

In a representative profile the surface layer is clay loam about 18-in thick. It is dark brown in the upper 6-in, dark grayish-brown in the middle 6-in, and brown in the lower 6-in. The underlying material extends to a depth of 87-in or more. The upper 3-in is pinkish-white indurated caliche, the next 57-in is pink silty clay loam, and the lower 9-in is light reddish-brown clay loam.

Mereta soils are well drained and have slow surface runoff. Permeability ranges from <0.6 to 0.20 in/hr in the indurated caliche. Available water capacity is low.

These soils are suited to crops or to use as range or wildlife habitat.

Angelo Series: The Angelo series consists of nearly level to gently sloping soils on smooth outwash plains.

In representative profile the surface layer is dark grayish-brown clay loam about 6-in thick. The next layer extends to a depth of 92-in. The upper 6-in is grayish-brown clay loam; the next 16-in is reddish-brown clay; the next 30-in is pink silty clay loam; and the lower 34-in is reddish-yellow clay loam. These soils are well drained and have slow surface runoff. Permeability is 0.2 to 0.6 in/hr. Available water capacity is high.

Soil characteristics and properties are summarized in Table 3.3-2.

Subsurface data obtained from some twenty-five soil borings scattered across the base tend to support the above discussions (Figure 3.3-6). In general, the borings reveal predominantly clay and caliche and/or gravelly clay and gravelly caliche soils with some sand. Overall, at GAFB, soils are moderately alkaline, possess permeabilities ranging from 0.2 to 2.0 in/hr and exhibit moderate runoff potentials. Of the twenty-five borings, specific water infiltration tests were run on material

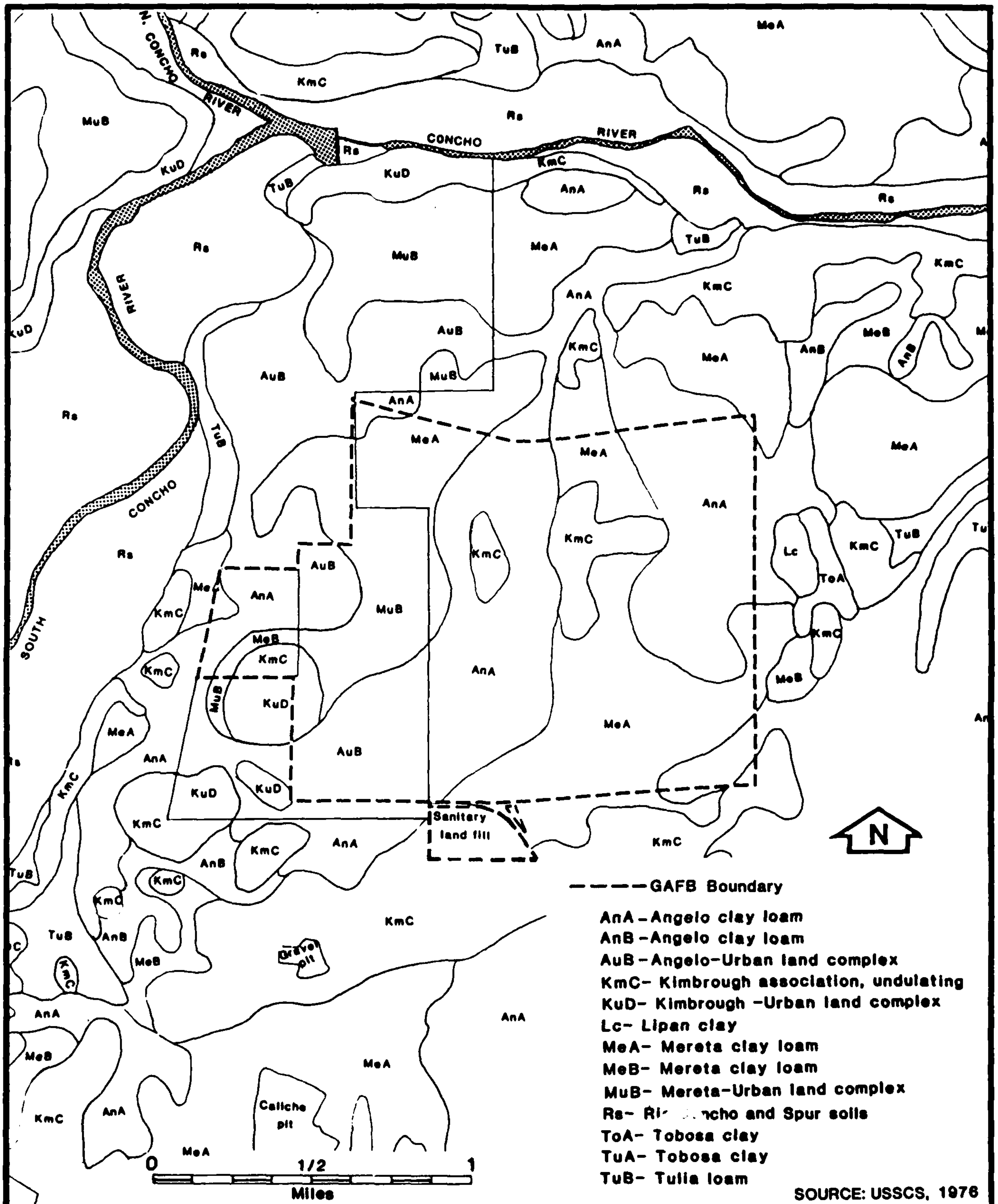

Figure 3.3-5
SOILS MAP-SAN ANGELO AREA

INSTALLATION
RESTORATION PROGRAM
Goodfellow Air Force Base

Table 3.3-1. Stratigraphy of the GAFB Area, San Angelo, Texas (Continued, Page 2 of 2)

System	Series	Group	Stratigraphic Unit	Approximate Maximum Thickness (ft)	Character of Rocks
Cambrian			Wilberns Formation		
			San Saba Limestone Member	400	Glauconitic limestone.
			Point Peak Shale Member	200+	Soft, greenish, calcareous shale with beds of dolomite and limestone. Reef-like masses of limestone.
			Morgan Creek Limestone Member	140	Medium to coarse-grained glauconitic limestone.
			Welge Sandstone Member	35	Brown, nonglauconitic sandstone.
			Riley Formation		
			Lion Mountain Sandstone Member	70	Glauconitic sandstone and limestone.
			Hickory Sandstone Member	500	Yellow, brown, and red sandstone. Thin lenses of red or gray.
	Precambrian rocks			--	Pink granite, dark grav schist, and pink gneiss.

Source: TDWR, 1979.

Table 3.3-1. Stratigraphy of the GAFB Area, San Angelo, Texas (Page 1 of 2)

System	Series	Group	Stratigraphic Unit	Approximate Maximum Thickness (ft)	Character of Rocks
Quaternary	Pleistocene to Present		Alluvium-Leona Formation of Local Usage	125	Sand, clay, silt, caliche, and gravel.
Cretaceous	Comanche	Washita Division	Buda Formation	40	Soft, gray, nodular limestone; marl; and thin, hard, granular limestone. Massive brittle limestone.
			Del Rio Formation	20	Clay, marl, and thin beds of marly limestone.
		Fredericksburg Division	Segovia Formation (Edwards Group)	300	Cherty limestone and dolomite, marly in part.
			Fort Terret Formation (Edwards Group)	140	Cherty limestone and dolomite, argillaceous in lower part.
		Trinity	Antlers Formation	100	White to red, fine to medium-grained sand with some beds of clay. Scattered lenses of gravel, in places conglomeritic at base.
Triassic		Dockum		200	Sandstone, clay, shale, and conglomerate.
Permian	Leonard	Pease River	Blaine Formation	300	Gypsiferous, varicolored sandstone and clay with thin sandstone beds and thin to massive gypsum beds.
			San Angelo Formation	250	Red sand and siltstone interbedded with clay, coarse cross-bedded sand, and basal conglomerate.
		Clear Fork	Choza Formation	625	Dolomite interbedded with varicolored clay.
			Vale Formation	140	Vale: Varicolored, sandy, gypsiferous shale.
			Arroyo Formation	60+	Arroyo: Alternating layers of shale and limestone.
	Wolfcamp	--	--	--	Limestone and Shale
Pennsylvanian	Cisco to Atoka	--	--	--	Limestone, shale, and sandstone.
Ordovician	--	Ellenburger	--	800	Gray to yellowish-gray, fine to coarse, crystalline limestones and dolomite with chert.

Table 3.4-1. Water Quality Data, O. C. Fisher Lake at San Angelo, Texas. Water Year: October 1981 to September 1982. (Continued, Page 2 of 3)

DATE	TIME	SAMPLING DEPTH (FEET)	SPECIFIC CONDUCTANCE (UMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	TRANSPARENCY (SECCHI DISK) (M)	OXYGEN, DISSOLVED (MG/L)	OXYGEN, DISSOLVED (PERCENT SATURATION)	COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)
FEB										
11...	1310	1.00	605	8.1	6.5	.80	11.4	97	K4	K6
11...	1312	10.0	602	8.1	6.5	--	11.3	97	--	--
11...	1314	20.0	602	8.1	6.5	--	11.3	97	--	--
11...	1316	28.0	607	8.1	6.5	--	10.9	93	--	--
APR										
28...	0947	1.00	664	8.2	17.0	.80	8.8	97	K7	74
28...	0949	10.0	665	8.2	17.0	--	8.7	96	--	--
28...	0951	20.0	667	8.1	17.0	--	8.4	92	--	--
28...	0953	28.0	660	7.8	16.0	--	6.2	67	--	--
AUG										
17...	0850	1.00	647	7.9	28.5	.90	8.3	114	K17	K29
17...	0852	10.0	654	7.7	27.5	--	6.4	86	--	--
17...	0854	20.0	658	7.1	27.5	--	1.1	15	--	--
17...	0856	29.0	661	7.2	27.0	--	1.1	15	--	--

DATE	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)
FEB									
11...	220	63	53	22	36	1.1	12	160	38
11...	--	--	--	--	--	--	--	--	--
11...	--	--	--	--	--	--	--	--	--
11...	220	58	51	22	36	1.2	13	160	40
APR									
28...	240	66	55	24	37	1.1	13	170	40
28...	--	--	--	--	--	--	--	--	--
28...	--	--	--	--	--	--	--	--	--
28...	240	74	58	24	38	1.2	14	170	40
AUG									
17...	210	73	44	25	45	1.5	13	140	40
17...	--	--	--	--	--	--	--	--	--
17...	--	--	--	--	--	--	--	--	--
17...	220	80	47	25	45	1.5	13	140	39

DATE	CHLORIDE, DISSOLVED (MG/L AS CL)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)	NITROGEN, NITRITE TOTAL (MG/L AS N)	NITROGEN, NO2+NO3 TOTAL (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	PHOSPHORUS, TOTAL (MG/L AS P)	IRON, DISSOLVED (UG/L AS FE)	MANGANESE, DISSOLVED (UG/L AS MN)
FEB									
11...	90	7.0	354	--	<.10	1.10	.010	<10	<1
11...	--	--	--	--	<.10	1.10	.010	40	20
11...	--	--	--	--	--	--	--	--	--
11...	89	7.0	354	--	<.10	1.10	.010	<10	2
APR									
28...	98	6.3	376	<.020	<.10	1.10	.010	18	<3
28...	--	--	--	--	--	--	--	--	--
28...	--	--	--	<.020	<.10	1.30	.040	40	<10
28...	90	7.3	374	.020	<.10	1.50	.050	150	21
AUG									
17...	99	8.1	358	--	<.10	1.30	.010	7	<1
17...	--	--	--	--	<.10	1.00	<.010	40	<10
17...	--	--	--	--	<.10	1.20	.020	40	<10
17...	100	8.8	362	--	<.10	1.30	.030	88	55

312907100311301 O. C. FISHER LAKE SITE CC

WATER QUALITY DATA, WATER YEAR OCTOBER 1981 TO SEPTEMBER 1982

DATE	TIME	SAMPLING DEPTH (FEET)	SPECIFIC CONDUCTANCE (UMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	TRANSPARENCY (SECCHI DISK) (M)	OXYGEN, DISSOLVED (MG/L)	OXYGEN, DISSOLVED (PERCENT SATURATION)
FEB								
11...	1330	1.00	608	8.2	7.0	--	12.2	105
11...	1332	7.00	609	8.1	6.5	--	11.8	101
APR								
28...	1012	1.00	665	7.8	18.5	.50	6.8	77
28...	1014	7.00	665	7.6	17.5	--	4.0	44
AUG								
17...	0920	1.00	661	8.3	29.5	--	6.7	94
17...	0922	7.00	683	7.1	28.5	--	.8	11

Table 3.4-1. Water Quality Data, O. C. Fisher Lake at San Angelo, Texas. Water Year: October 1981 to September 1982. (Continued, Page 3 of 3)

DATE	TIME	SAMPLING DEPTH (FEET)	SPECIFIC CONDUCTANCE (UMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	TRANSPARENCY (SECCHI DISK) (M)	TURBIDITY (FTU)	OXYGEN, DISSOLVED (MG/L)	OXYGEN, DISSOLVED (PERCENT SATURATION)	COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML)
FEB										
11...	1350	1.00	715	8.1	8.0	.60	--	11.8	104	<1
11...	1351	1.00	--	--	--	--	--	--	--	--
11...	1352	10.0	1090	7.8	8.0	--	--	11.5	102	--
11...	1354	13.0	1080	7.8	8.0	--	--	11.2	99	--
APR										
28...	1040	1.00	853	7.9	18.5	.60	--	7.5	85	K6
28...	1041	.75	--	--	--	--	--	--	--	--
28...	1042	11.0	1050	7.4	17.5	--	--	3.2	36	--
AUG										
17...	0935	1.00	681	7.8	30.5	.60	.60	7.3	104	K8
17...	0936	1.00	--	--	--	--	--	--	--	--
17...	0937	11.0	696	6.8	28.5	--	--	.3	4	--

DATE	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)
FEB										
11...	K5	270	94	62	29	41	1.2	11	180	51
11...	--	--	--	--	--	--	--	--	--	--
11...	--	--	--	--	--	--	--	--	--	--
11...	--	440	190	92	52	62	1.4	5.0	250	91
APR										
28...	200	320	130	69	37	50	1.3	9.8	190	65
28...	--	--	--	--	--	--	--	--	--	--
28...	--	400	180	82	48	62	1.5	6.7	220	88
AUG										
17...	96	230	76	46	27	48	1.5	13	150	44
17...	--	--	--	--	--	--	--	--	--	--
17...	--	240	72	54	26	45	1.4	13	170	40

DATE	CHLORIDE, DISSOLVED (MG/L AS CL)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)	NITROGEN, NITRITE TOTAL (MG/L AS N)	NITROGEN, NO2+NO3 TOTAL (MG/L AS N)	NITROGEN, AMMONIA TOTAL (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	PHOSPHORUS, TOTAL (MG/L AS P)	IRON, DISSOLVED (UG/L AS FE)	MANGANESE, DISSOLVED (UG/L AS MN)
FEB										
11...	110	7.2	419	--	<.10	--	1.10	.010	10	2
11...	--	--	--	--	--	--	--	--	--	--
11...	--	--	--	--	--	--	--	--	--	--
11...	180	13	645	--	<.10	--	.87	.010	64	12
APR										
28...	140	9.3	494	<.010	<.10	<.060	1.30	.080	12	4
28...	--	--	--	--	--	--	--	--	--	--
28...	180	14	613	<.020	<.10	--	.92	.030	15	41
AUG										
17...	100	10	378	--	<.10	--	1.40	.020	9	2
17...	--	--	--	--	--	--	--	--	--	--
17...	100	14	395	--	<.10	--	2.60	.090	810	410

Source: USGS, 1982.

Table 3.4-2. Water Quality Data, Twin Buttes Reservoir near San Angelo, Texas. Water Year: October 1981 to September 1982.

DATE	TIME	SPECIFIC CONDUCTANCE (UMHOS)	TEMPERATURE (DEG C)	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)
OCT 20...	0930	720	14.5	210	48	42	25	64

DATE	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)
OCT 20...	2.2	5.7	160	50	110	.4	13	406

Source: USGS, 1982.

Table 3.4-3. Water Quality Data, Lake Nasworthy near San Angelo, Texas. Water Year: October 1981 to September 1982.

DATE	TIME	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	TEMPER-ATURE (DEG C)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
OCT 20...	0830	850	21.0	230	57	48	26	88

DATE	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
OCT 20...	2.8	5.1	170	64	150	.5	16	500

Source: USGS, 1982.

Table 3.4-4. Water Quality Data, North Concho River at San Angelo, Texas. Water Year: October 1981 to September 1982.

DATE	TIME	STREAMFLOW, INSTANTANEOUS (CFS)	SPECIFIC CONDUCTANCE (UMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	TURBIDITY (FTU)	OXYGEN, DISSOLVED (MG/L)	OXYGEN, DISSOLVED (PERCENT SATURATION)	OXYGEN DEMAND, BIOCHEMICAL, 5 DAY (MG/L)	HARDNESS (MG/L AS CACO3)
FEB 11...	0950	1.4	2180	8.0	7.5	5	6.5	15.7	138	2.9	620
APR 28...	1525	1.6	1930	7.9	22.5	5	21	13.9	172	4.9	530
AUG 17...	1110	.68	1720	7.4	28.0	10	11	7.8	105	5.8	470

DATE	HARDNESS, NONCARBONATE (MG/L CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	SODIUM AD-SORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)
FEB 11...	260	110	84	220	3.8	5.7	360	180	420	1.2	23
APR 28...	220	98	69	200	4.3	5.6	310	140	370	1.0	17
AUG 17...	170	75	69	190	4.4	5.5	300	120	350	1.0	23

DATE	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)	SOLIDS, RESIDUE AT 105 DEG. C, SUSPENDED (MG/L)	SOLIDS, VOLATILE, SUSPENDED (MG/L)	NITROGEN, NITRATE TOTAL (MG/L AS N)	NITROGEN, NITRITE TOTAL (MG/L AS N)	NITROGEN, NO2+NO3 TOTAL (MG/L AS N)	NITROGEN, AMMONIA TOTAL (MG/L AS N)	NITROGEN, ORGANIC TOTAL (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	PHOSPHORUS, TOTAL (MG/L AS P)	CARBON, ORGANIC TOTAL (MG/L AS C)
FEB 11...	1260	16	12	2.0	.030	2.0	<.060	--	1.10	.020	5.4
APR 28...	1090	34	7	1.5	.070	1.6	<.060	--	1.40	.070	8.8
AUG 17...	1010	31	2	.86	.060	.92	.380	1.2	1.60	.050	8.3

DATE	TIME	ARSENIC DISSOLVED (UG/L AS AS)	BARIUM, DISSOLVED (UG/L AS BA)	CADMIUM DISSOLVED (UG/L AS CD)	CHROMIUM, DISSOLVED (UG/L AS CR)	COPPER, DISSOLVED (UG/L AS CU)	IRON, DISSOLVED (UG/L AS FE)
FEB 11...	0950	6	200	1	10	1	30
APR 28...	1525	5	150	<3	<10	1	9
AUG 17...	1110	6	190	<1	<10	1	9

DATE	LEAD, DISSOLVED (UG/L AS PB)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, DISSOLVED (UG/L AS SE)	SILVER, DISSOLVED (UG/L AS AG)	ZINC, DISSOLVED (UG/L AS ZN)
FEB 11...	<1	10	.2	1	<1	10
APR 28...	1	24	<.1	1	<1	<12
AUG 17...	<1	12	.2	<1	<1	7

Source: USGS, 1982.

3.4.2 GROUND WATER

Overall water quality of ground water supplies in the area of GAFB is quite variable and depends largely on the aquifer characteristics. Analyses of ground water from the area indicate that all water may be classified as hard. The following discussion is taken from Dennis (1970) and TDWR (1954) and offers a general summary of the water quality of the principal aquifers.

Very large quantities of water are in storage in the Hickory Sandstone and possibly the Wilberns and other Paleozic Formations. Analyses of water obtained from the Hickory Sandstone indicate hot moderately mineralized supplies.

Water from the dolomitic limestone beds in the outcrop areas of the formations of the Clear Fork Group contains dissolved solids ranging from 300 to 3,900 parts per million (ppm). The principal ions present in the water are calcium, bicarbonate and sulfate, and in general the water is excessively hard.

The outcrop areas of formations in the Pease River Group contain water that ranges from 800 to 52,000 ppm in dissolved solids. In general, the water in the formations of the Pease River Group is highly mineralized.

Water in the formations of the Trinity and Fredericksburg groups contains dissolved solids ranging from 200 to 300 ppm. The water is hard, but in general it is better in quality than other ground water in the county.

The Leona Formation contains water that ranges from 500 to 1,400 ppm in dissolved solids. The predominant ions in the water are calcium and bicarbonate, and in general the water is excessively hard.

The water in the stream-channel deposits of Recent age contains approximately 200 to 300 ppm of dissolved solids.

The percentage of sodium is low in most of the ground water samples in Tom Green County for which it was calculated. Eleven analyses of water

from the principal aquifers show a range of 0.18 to 0.77 ppm of boron, which is not excessive for most crops. Analyses for fluoride were made on 67 samples of water and the fluoride content ranges from 0.1 to 3.1 ppm; however, most of the samples of potable water contain less than 1 ppm of fluoride.

As noted, there are no wells present at GAFB. Potable water requirements are satisfied by the city of San Angelo municipal system. Irrigation water is obtained from direct pumping of the Concho River.

Water quality analyses of ground water obtained from wells in the proximity of GAFB are summarized in Table 3.4-5.

3.5 BIOTA

Biota characteristics of GAFB are typical of maintained/landscaped areas of west-central Texas. Habitats are a combinations of lawns and landscaped areas (cantonment area) and more natural grassland/weed habitat (airfield and perimeter). Habitats of value to wildlife are essentially non-existent on GAFB.

No permanent surface water exists on GAFB. Surface drainage ditches and depressions do temporarily contain water during periods of heavy precipitation. No manmade lakes or ponds exist on GAFB.

Common wildlife species on GAFB include:

Birds:
- Common grackle;
- Boat-tailed grackle;
- Starling;
- Mourning dove;
- Scissor-tailed flycatcher;
- Barn swallow;
- House sparrow;
- Northern mockingbird;
- Northern cardinal; and
- Horned lark.

Mammals:
- Franklin ground squirrel;

Table 3.4-5. Analyses of Water From Wells in the Area of GAFB

Well	Owner	Well (ft)	Date of Collection	Specific Conductance (µmho at 25°C)	pH	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)
G-18	Roy Wiegman	135	Oct. 11, 1948	7,810	--	11	904	340
G-19	J. M. Brandon	63	Oct. 11, 1948	1,280	--	19	93	57
H-69	W. E. Phillips	73	Oct. 12, 1948	2,630	--	32	194	110
H-70	J. W. Nelson	80	Oct. 16, 1948	3,030	--	16	228	158
H-108	Jewel Brandon	80	Oct. 12, 1948	3,210	--	4.8	308	138
H-109	Mrs. E. C. Adkinson	112	Oct. 3, 1940	--	--	--	536	167

Well	Sodium and Potassium (Na + K)	Bicarbonate (HOO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Boron (B)	Fluoride (F)	Dis-solved solids (sum)	Total Hardness as $CaCO_3$	Percent Sodium
G-18	431	308	1,470	1,990	3.5	--	--	5,300	3,650	20
G-19	80	364	98	152	32	--	--	a772	466	27
H-69	186	314	263	560	24	--	--	1,520	936	30
H-70	121	90	217	830	13	--	--	1,630	1,220	18
H-108	210	64	912	560	2.5	--	--	2,170	1,340	26
H-109	265	244	1,880	314	c	--	--	3,280	2,020	--

Source: TDWR, 1954

Eastern fox squirrel;
Eastern cottontail;
Blacktail jackrabbit; and
House mouse.

Additional bird species would occur as migrants during spring and late fall. Numerous other mice and mole species would be found in the more remote grassland areas (e.g., airfield areas).

No threatened or endangered species are known or likely to occur on GAFB. Existing activities and operations are not known to have any impact on existing habitats or wildlife.

4.0 FINDINGS

This chapter presents information for GAFB on wastes generated by activity, describes past waste disposal practices, identifies the disposal and spill sites located on the base, and evaluates the potential for environmental contamination. This information was obtained by a review of files and records, interviews with current and former personnel, and site inspections.

4.1 ACTIVITY REVIEW

4.1.1 INDUSTRIAL OPERATIONS

Current industrial operations at GAFB are very limited. Vehicle and aircraft maintenance is limited to maintenance of base vehicles at the Transportation Motor Pool, maintenance of private vehicles at the Auto Hobby Shop, and maintenance of aircraft operated by the Aero Club. The only other industrial operations are the facilities maintenance shops operated at 3480th Civil Engineering Squadron (CES); the Morale, Welfare and Recreation (MWR) Photo Hobby Shop; Reproduction, and Computer Maintenance at the Security School.

The GAFB mission underwent a major change in 1958. At that time, command of the base was transferred from ATC to USAF Security Service. This terminated the flying mission at GAFB, which had operated as a basic pilot training school since 1941. This change resulted in a drastic drop in the level of industrial operations.

Before 1958, the pilot training and support units at GAFB provided a full range of aircraft maintenance including painting, engine repairs, and aircraft systems maintenance. These operations were concentrated in the three main hangars along the flightline, which have since been converted to other uses. Building 209, which once housed the paint, motor cleaning, and aircraft systems shops, has been converted into a commissary along with Building 222, which was previously the base engineering shops. Building 340, previously an organizational level maintenance hangar, is now used for similar purposes by the Aero Club. Building 431, another former organizational level maintenance hangar, is

now used by Department of Transportation (DOT) to support an automobile testing program on a tenant basis.

Of the current industrial operations, the Transportation Motor Pool is the largest. This operation has operated from its current location in Building 421 -'nce the 1940's. It provides the full range of vehicle maintenance, including painting, engine repairs, and general repairs. The MWR Aero Club provides similar support of four single reciprocating engine aircraft. Personnel using the MWR Auto Hobby Shop in Building 509 perform mostly routine maintenance such as oil changes, although the shop is equipped for most types of automotive maintenance except painting. Shops operated by the 3480th CES include paint, small engine, exterior electric, refrigeration, and entomology. These shops are all located in the 700 area, and provide maintenance for buildings and grounds on GAFB.

Training at GAFB is limited to that provided by the Security School. Firefighter training exercises involving live fires are conducted at an off-base facility operated by the City of San Angelo.

4.1.2 FUELS/OILS HANDLING AND STORAGE

Due to lack of a flying mission, fuels required at GAFB are limited. Bulk fuel storage is provided for Diesel Fuel (DF) and gasoline (MOGAS). The largest storage point is the Base Exchange (BX) Service Station, as shown in Table 4.1-1. Before 1958, fuel to support the flying mission was dispensed from a group of nine 25,000 gallon (gal) UG storage tanks located along the east side of Fort McKavitt Road, just north of Building 300. These tanks were used for bulk storage. Fuel was transported to flightline fueling areas in tank trucks which were filled from a large fill stand above the tanks. When this practice was discontinued the tanks were left in place. They were finally removed by a salvage contractor in 1976. Two additional tanks which were previously used to store fuel at the Transportation Motor Pool were abandoned in the late 1970's. One was subsequently excavated, the other is still in place, but was emptied when abandoned.

Table 4.1-1. POL Storage Locations

Building	Tank Capacity (gal)	Contents	Type
741	4,000	DF	UG
520	1,000	DF	UG
904	600	Oil	UG
904	16,000	MOGAS	UG
715	7,500	Asphalt	AG
DOT	2,500	MOGAS	UG
DOT	500	DF	AG

Source: ESE, 1984.

4.1.3 PESTICIDE/HERBICIDE HANDLING STORAGE

Pesticide/herbicide handling and storage is a consolidated operation at GAFB.

Building 741 is utilized for storage of all pesticides/herbicides utilized on GAFB. The area adjacent to Building 741 is used for equipment storage and mixing. The area contains a dedicated wash rack and mixing sink. Both drain into a holding tank which collects all rinse water from mixing and cleaning operations. The tank is pumped out after use, and the contents are containerized for future use as makeup water.

Prior to approximately 18 months ago, the wash rack by Building 717 was used for equipment cleaning, and all rinse water entered the sanitary sewer system.

Application of pesticides/herbicides on GAFB is largely restricted to weed control in cantonment area and pest control inside buildings (Table 4.1-2).

Empty containers are triple rinsed, crushed, and sent to the sanitary landfill. No waste or excess pesticide/herbicide stocks are generated on GAFB.

4.1.4 PCB HANDLING AND STORAGE

Transformers and other electrical items which could potentially contain polychlorinated biphenyls (PCBs) are sampled when taken out of service. Approximately 10 such items are handled each year. They are held on a concrete pad near Building 716 until analytical results are available. All items are subsequently disposed of through Defense Property Disposal Office (DPDO). Since 1978 only one PCB-contaminated item has been found. This transformer, containing 97 ppm PCB, was damaged during transfer operations in the supply yard at Building 511. The resulting spillage was absorbed with sand, which was awaiting disposal at the time of the site visit.

Table 4.1-2. One Quarter Usage of Pesticides/Herbicides on GAFB

Pesticide	Active Ingredient Quantity (lbs)
Aldrin	24
Diazinon	15
Organophosphates	107
P-Dichlorobenzene	40
Strychnine	5

Source: Pest Control Summary Report, April-June, 1984.

installed to the depth of bedrock, and the screen should extend over the entire saturated interval and approximately 1 ft above the water table. The wells need to be screened above the water table to detect nonmiscible, floating contaminants, such as petroleum products. Borehole geophysical logging of all GAFB wells is recommended to facilitate stratigraphic analysis. During drilling, Shelby tube samples should be taken to provide soils data and vertical permeability measurements. The top of the filter pack should be bentonite-sealed, and the annulus should be grouted to the surface. The well should be protected with pipe fitted with locking caps. The well should be developed to the fullest extent possible and surveyed both vertically and horizontally by a registered surveyor to obtain accurate well location distances and water level elevations. Water levels should be measured after recovery from well development and at the time of sampling. Slug tests should be conducted to determine horizontal permeability and to provide data for evaluation of flow rates.

Prior to initiation of any Phase II field activities, a detailed work plan should be prepared. This work plan should provide specific procedures to be followed in well construction, well logging, well installation, well development, surveying, water level measurements, aquifer testing, sampling, laboratory analysis, quality control, and reporting. All samples should be analyzed at a minimum for total petroleum hydrocarbons, halogenated and nonhalogenated solvents, metals, PCBs, and pesticides, using EPA-approved procedures. The solvent analytes should include at a minimum trichloroethylene (TCE), benzene, methyl isobutyl ketone (MIBK), carbon tetrachloride, methyl ethyl ketone (MEK), methylene chloride, and acetone. The metal analytes should include cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc. The recommended parameters include those compounds known or suspected to have been placed in the disposal sites. In addition, certain additional parameters for which drinking water standards exist are included. It is recommended that chemical analysis for metals include both total and dissolved fractions to quantify which metals are mobile, as well as the total amount of metal sorbed onto suspended materials and, hence, potentially available for leaching.

6.0 RECOMMENDATIONS

The information gathered through interviews and research were sufficient to locate and categorize the onbase disposal sites. A Phase II monitoring program is recommended to accomplish the following objectives:

1. Obtain additional information regarding aquifer characteristics below GAFB. Such information would include stratigraphy, direction of ground water flow, and permeability.
2. Determine the nature and extent of surface water, ground water, soil, and sediment contamination that might have resulted from past storage, handling, and disposal practices.

6.1 PHASE II MONITORING RECOMMENDATIONS

The following actions are recommended to further assess the potential for environmental contamination from waste disposal areas at GAFB. The recommended actions are intended to be used as a general guide in the development and implementation of the Phase II study. The recommendations include the approximate number of ground water monitoring wells, type(s) of samples to be collected (e.g., soil, water, sediment) and suspected contaminants for which analyses should be performed. The number of ground water monitoring wells recommended corresponds to the number of wells required to adequately determine whether contaminants are migrating from a given source. The final number of ground water monitoring wells required to determine the extent of and define the movement of contaminants from each site will be determined as part of the Phase II investigation.

Recommended ground water monitoring should be performed in order to assess contaminant migration under different ground water conditions. After monitoring, the data should be evaluated to determine the need for further action (if any). All drilling activities should be conducted by licensed water well driller. All monitoring wells should be constructed of threaded-joint casing and factory-slotted screen. Under no circumstances should polyvinyl chloride (PVC) primer or PVC glue be used for the construction of well casing or bailers. The wells should be

water does not occur at less than 50 ft depths. Limited potential for contamination exists. The HARM Score for this site is 37.

Fuel Storage Area

During the period of aircraft operations at GAFB, this area served as the main fuel storage site. It contained nine 25,000 gal underground (UG) tanks and dispensing facilities for filling trucks. Possible leakage was reported when the tanks were excavated in 1976. Whether the tank leaked prior to the removal operation or resulted from the excavation itself could not be determined. Contaminated soils was reported removed by the salvage contractor who removed the tanks. The HARM Score for this site is 4.

5.0 CONCLUSIONS

The goal of the IRP Phase I study is to identify sites where there is potential for environmental contamination resulting from past waste disposal practices and to assess the probability of contaminant migration from these sites. The conclusions are based on the assessment of the information collected from the Project Team's field inspection, review of records and files, review of the environmental setting, and interviews with base personnel, past employees, and state and local government employees.

<u>South Landfill</u>

This site was operated as a general purpose trench and fill landfill from 1950 to 1970. It includes an area used as a fire training pit from 1953 to 1958. Little waste segregation was practiced during the period of operation, and no restrictions were placed on materials landfilled. Contents include industrial waste and containerized liquids. Soil permeability is 0.06 to 0.6 inches per hour (in/hr). Ground water occurs at depths of 30 to 60 ft. The potential exists for contamination and/or migration involving solvents, fuels and oils. The HARM Score for this site is 58.

<u>Drum Storage Area</u>

This site was used to store several hundred drums in the early 1950's. Photographic evidence of extensive surface spillage exists, but little else is known about the site. The area was regraded in approximately 1953. Potential exists for residual POL contamination in soils. Soil permeability is 0.06 to 2.0 in/hr, and depths to water are 30 to 60 ft. The HARM Score for this site is 42.

<u>Southeast Landfill</u>

Operated as a trench and fill landfill beginning in 1970, this site was closed in 1982. During this period, industrial operations at GAFB were very limited. Landfill contents may include small containers of solvent, fuels, and oils. Soil permeability is 0.06 to 0.20 in/hr and ground

Table 4.4-1. Summary of HARM Scores

Rank	Site	Receptors	Waste Characteristics	Pathways	Waste Management Factor	Total
1	South Landfill	68	80	26	1.0	58
2	Drum Storage	68	32	33	0.95	42
3	Southeast Landfill	68	16	26	0.95	35
4.	Fuel Storage Area	65	24	33	0.10	4

Source: ESE, 1984.

Each of the sites discussed in Section 4.3 was rated using the HARM. The HARM scores are summarized in Table 4.4-1. The process of rating potential hazards using the HARM system is described in detail in Appendix F. Basically the method uses numerical ratings for a number of discrete variables to calculate subscores for three categories. These categories represent the risk of human exposure (Receptors), the nature and quantity of waste (Waste Characteristics), and the potential migration routes (Pathways).

Waste characteristics were evaluated based on information obtained in interviews with base personnel. In cases where the waste was a mixture of substances with differing characteristics, the most critical waste was used for each variable. For example, a mixture of metal treatment sludges and waste solvents might be rated high for flammability due to the solvents and high for persistence due to the metals in the sludge. This is based on the guidance provided for HRS.

For the Pathways subscore, environmental factors such as rainfall intensity and net precipitation were evaluated using standard references such as the Climatic Atlas of the United States (USGS, 1979). Erosion potential was based on direct observation, whereas depth to ground water was based on available boring logs, geologic data, and interviews. A multiplication factor to account for Waste Management Practices is applied to the average of the three subscores to yield a final score. HARM provides only three choices (1.0, 0.95, and 0.1) to indicate no containment, limited containment, and fully contained and in full compliance.

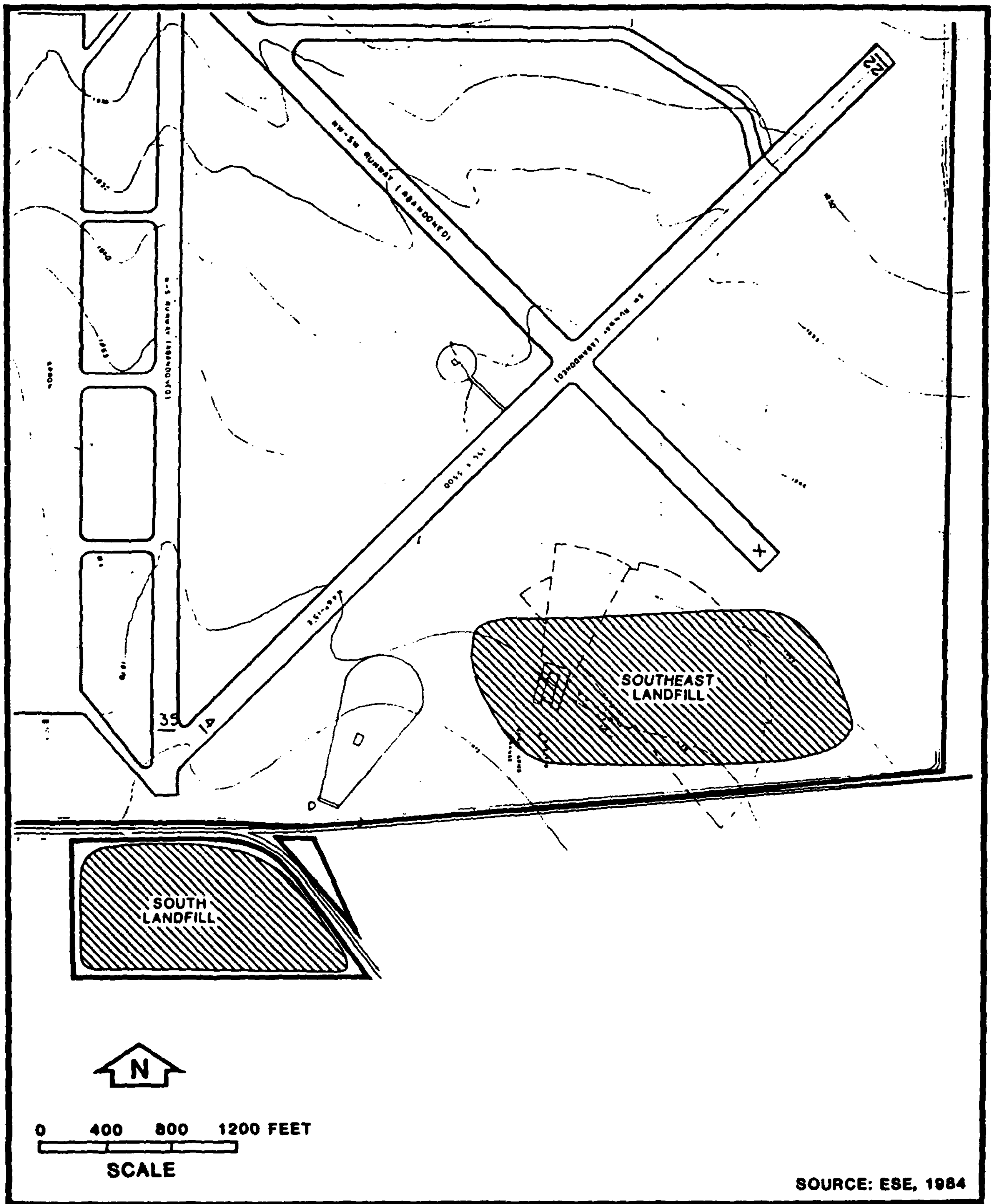

Figure 4.3-3
ENLARGEMENT OF
POTENTIAL CONTAMINATION
(SOUTHEAST SECTION)

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Drum Storage Area

Photographs from 1950 show a large drum storage area at the north end of the flightline, near the main gate. There is visible evidence of spillage, and several hundred drums are present. No records were available to document the contents of these drums, but they are presumed to have contained POL. This area was regraded in 1953, apparently in conjunction with the destruction of an earthen berm used to contain fire from an adjacent firing range.

Southeast Landfill

In 1970, landfilling operations shifted to this site in the southeast corner of the base. It was operated by the same trench and fill method, with trenches approximately 15 ft deep. The site was used as a general purpose landfill until 1982. Material deposited here was predominantly household solid waste. Small quantities of industrial waste such as oil and solvents may also have been included. Most of this area was converted to a small arms and skeet range; the rest is an open area.

Fuel Storage Area

During the period of aircraft operations at GAFB, this area served as the main fuel storage site. It contained nine 25,000-gal UG tanks and dispensing facilities for filling trucks. Some visible evidence of possible leakage was reported when the tanks were excavated in 1976. Whether leakage occured prior to removal or resulted from contractor excavation is uncertain. Contaminated soil was reported removed by the salvage contractor who removed the tanks. No information was available on quantities of soil removed or where it was ultimately disposed of.

4.4 HAZARD ASSESSMENT

Of the four areas of potential contamination identified, three were recommended for Phase II investigations based on the decision tree illustrated in Figure 1.3-1. The Fuel Storage Area was not recommended for further IRP action due to the lack of potential for contamination and migration.

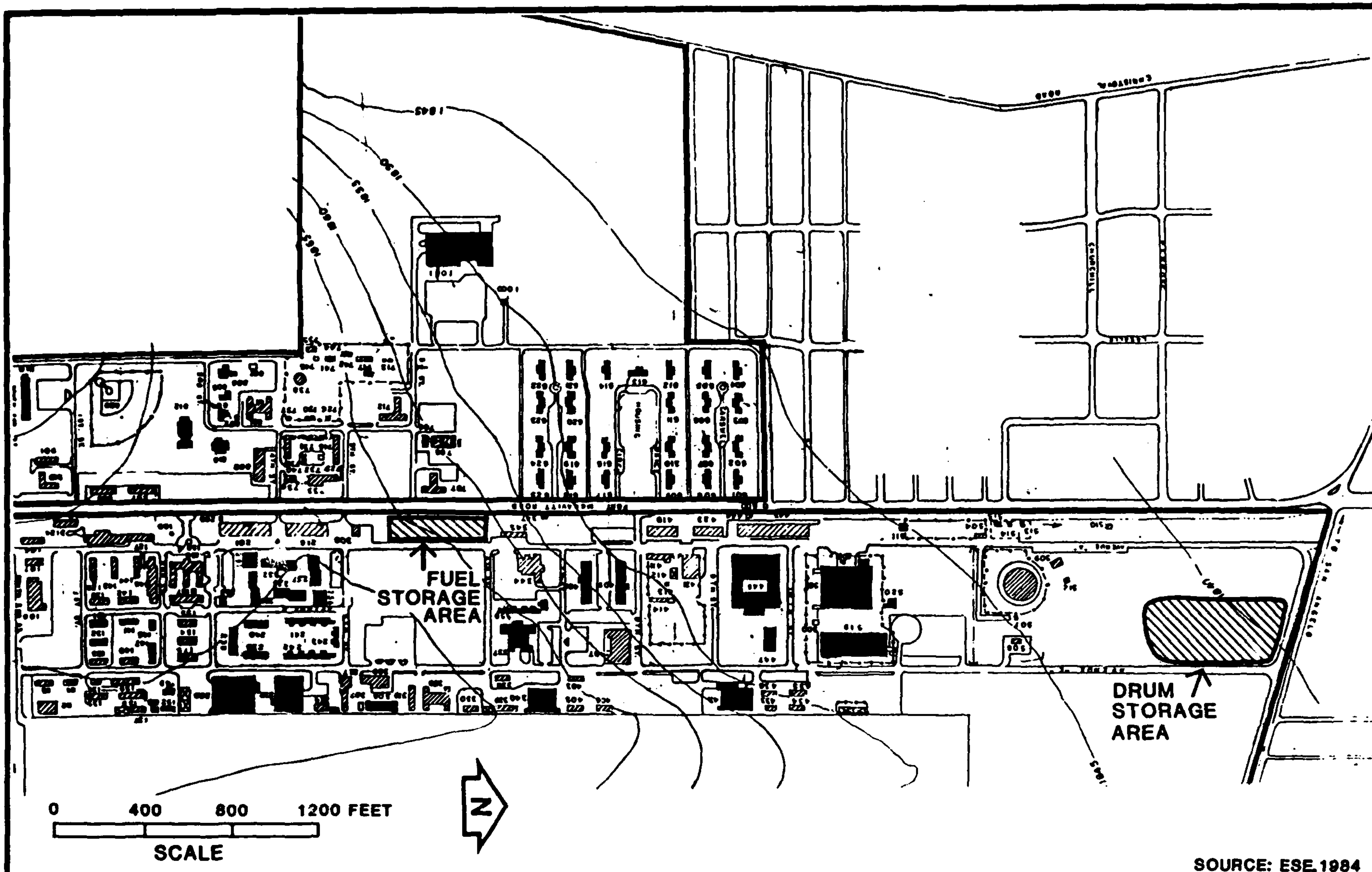

Figure 4.3-2
ENLARGEMENT OF POTENTIAL CONTAMINATION
(WEST SECTION)

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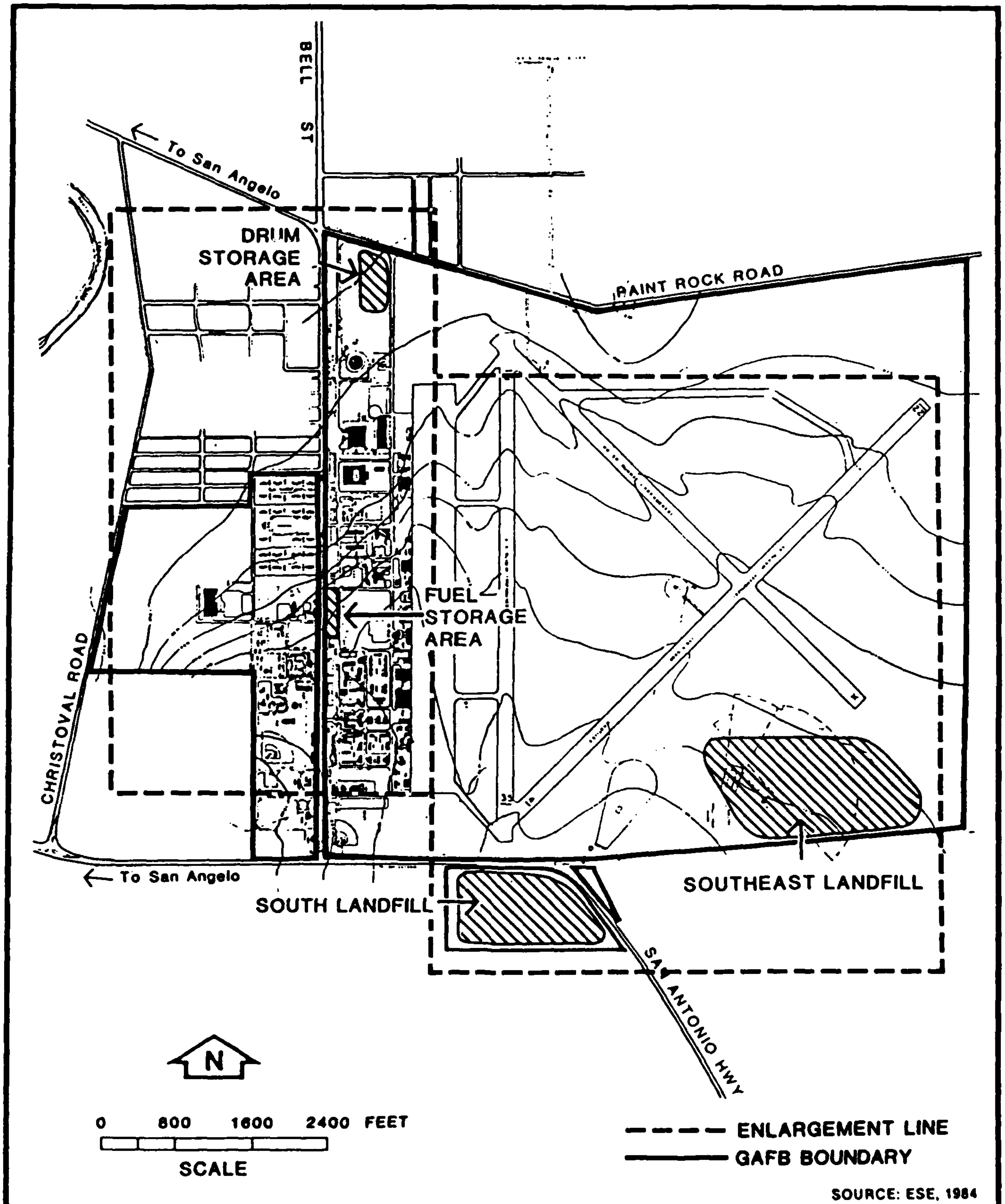

Figure 4.3-1
AREAS OF POTENTIAL CONTAMINATION

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for virtually all wastes into the 1970's. At that time, waste segregation was initiated. Most industrial waste began to be collected in drums for disposal through DPDO. Isolated incidents of disposal in landfills and oil spreading for dust suppression continued until approximately 1980.

In 1982, the base sanitary landfill was closed. Since that time, on base waste disposal has been limited to the disposal of construction rubble and fill dirt in the south landfill.

4.2.3 SPILLS OR INCIDENTAL DISCHARGES

Available records at GAFB provide no record of reportable fuel spills requiring emergency response or cleanup efforts. Spills that may have been associated with aircraft operation were not subject to formal reporting requirements.

One known PCB spill has occurredat GAFB. The incident occurred in the vicinity of Building 511, as described in Section 4.1.4.

4.3 AREAS OF POTENTIAL CONTAMINATION

This study identified four areas at GAFB subject to contamination by industrial and/or hazardous waste as a result of handling and disposal practices. Figures 4.3-1 through 4.3-3 illustrate the location of these areas.

South Landfill

This site is located at the south end of the base, across the road from the end of Runway 35. It was used as a general purpose landfill from at least 1950 to 1970. It includes an area which was used as a firefighter training pit from 1953 to 1958. This area, which was used to train a firefighting force numbering over 100, was subsequently reworked as part of the landfill. The landfill was operated using the trench and fill method, with the trench bottom at a depth of approximately 15 ft. No restrictions were placed on items dumped. In addition to household solid waste, industrial wastes including containerized liquids were routinely landfilled. This site is currently used as a rubble dump.

Table 4.2-1. Other Chemicals Used at GAFB (Continued, Page 2 of 2)

Shop	Location	Waste	Quantity Used* gal/yr
Computer Maintenance	501	TCE	1 spray can/yr
	519	Methanol	2
	407	Acetone	25
		Dichlorodi-fluoromethane	NA
		Xylene	1 pt/yr
Refrigeration	725	Coolant	
		Dichlorodi-fluoromethane	NA
Entomology	741	Strychnine	20 lbs
		Organo-phosphate	428 lbs
		Paradichloride	160 lbs
		Diazinon	60 lbs
		Aldrin	96 lbs
Reproduction	141	Naphtha	60 lbs
Clinic	1001	Methanol	9
		Acetone	9
		Formaldehyde	6
		Ethyl ether	1 pt/yr
		Phenol	1 pt/yr
		Chloroform	2 pt/yr
		Xylene	1 pt/yr
		Acetone	6
Photo	114	Trichloroethane	NA

Legend: * gal/yr = gallon(s) per year.
pt/yr = pints per year
lbs = pounds
NA = Not Available

Source: ESE, 1984

Table 4.2-1. Industrial Operations (Shops)-- Waste Generation (Page 1 of 2)

Shop	Location	Waste	Quantity* gal/yr	Disposal†
Vehicle Maintenance	421	Waste Oil	300	CD
		Solvent	100	CD
		Paint/Thinner	100	CD
Auto Hobby	509	Waste Oil	300	CD
		Solvent		
Aero Club	340	Waste Oil	50	CD
Electric	725	Transformers	10/yr**	CD
BX Gas Station	904	Waste Oil	50	CD
Paint	740	Thinner	50	CD
Small Engine	717	Oil	50	CD
Photo	114	Developer/Fixer	NA	SS
Clinic	1001	Developer	NA	SS

Legend: * gal/yr = gallon(s) per year
pt/yr = pints per year
lbs = pounds
NA = Not Available
† CD = Contract Disposal
SS = Sanitary Sewer
** = 10 transformers/year, liquid quantity varies

Source: ESE,1984

4.2 HAZARDOUS WASTE GENERATION/DISPOSAL

4.2.1 GENERATING OPERATIONS

GAFB personnel provided a current list of industrial operations and waste generation. Based on this listing, GAFB has applied for nonhandler status under State of Texas regulations, indicating that existing operations are not generating wastes which qualify as hazardous under RCRA. Due to the limited extent of industrial operations, waste production is limited to waste oil, spent solvent, and paint waste. Interviews were conducted with personnel from each of the waste-generating operations to confirm waste quantities and disposal methods. Information obtained on waste-generating operations is summarized in Table 4.2-1, which also lists materials employed in consumptive use operations.

Information on waste generation during the flying mission years at GAFB was generally not available. Long-time employees confirmed that in accordance with the higher level of activity, much greater quantities of waste oil, solvent, and paints were handled. However, no accounting was kept of such materials, so no documentation of quantities is available. It is likely that wastes produced during this period included other items not currently used such as metal plating and/or cleaning solutions. No information was found to suggest the presence of munitions or agents, with the exception of small arms.

4.2.2 DISPOSAL OPERATIONS

The information obtained on waste disposal practices is summarized in Table 4.2-1. The general trend over the years since GAFB began operations has been from largely unsegregated disposal in base landfills to contract disposal. Before 1960, containerized liquids were routinely buried in base landfills. Over this same period, the firefighter training area was used as a general dumping ground for fuel, oil, and solvents. This area was later incorporated into the landfill.

When the GAFB flying mission ended, waste generation dropped dramatically. Thus the incidence of industrial waste landfilling dropped as well; however, base landfills continued to be used as disposal sites

Because the oil and grease analysis by EPA Method 413.2 does not differentiate between extractables of biological origin or the mineral oils and greases of POL origin, the EPA Infrared (IR) Spectrophotometric Method for total recoverable petroleum hydrocarbons (EPA Method 418.1) is recommended for assessing POL contamination. Halogenated and nonhalogenated solvents, PCBs, and pesticides may be analyzed by EPA Methods 624 and 625 or comparable methods. All water samples should be analyzed for pH, conductivity, and oxidation-reduction potential at the time of sampling.

For the south landfill, it is recommended that four monitoring wells be installed around the known fill areas (Figure 6.1-1). Available information indicates that some residents of developing areas to the east and north may be using local ground water supplies for drinking. Care should be taken in designing the Phase II study to insure that any potential for contamination of aquifers being utilized for potable supplies is properly addressed.

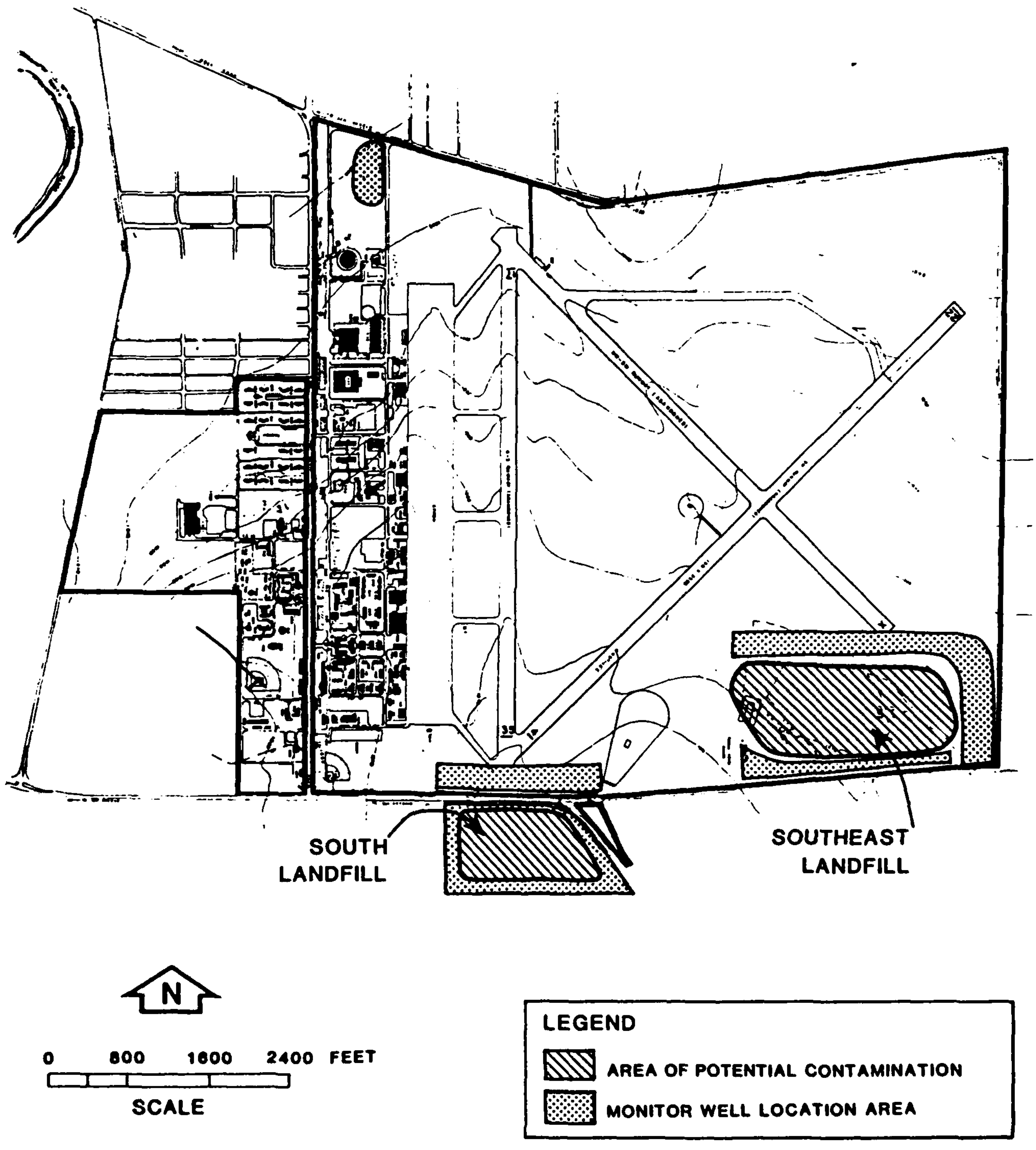
For the southeast landfill, four wells are recommended around the site, so as to establish the ground water gradient. Base personnel have been in contact with the State of Texas regulatory personnel concerning this landfill over the years. Phase II monitoring should be consistent with any closure requirements imposed by the state.

It is also recommended that composite soil samples be taken from the upper 6 ft of soil in the drum storage area. If significant contamination is found, the addition of monitoring wells should be considered. Table 6.1-1 summarized the recommended monitoring for GAFB Phase II investigations.

6.2 LAND USE GUIDELINES

Careful consideration should be given to the uses made of the disposal areas for the following reasons:

1. To provide the continued protection of human health, welfare, and the environment;



SOURCE: ESE, 1984

Figure 6.1-1
MONITOR WELL LOCATION AREA

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Table 6.1-1. Summary of Recommended Monitoring for GAFB Phase II Investigations

Site	HARM Score	Recommended Sampling	Recommended Analysis
South Landfill	58	Install four wells around known fill area, Three on north side one of south so as to establish gradient. Screen as necessary. Sample uppermost water bearing zone and drinking supplies considered at risk.	Total petroleum hydrocarbons, halogenated and nonhalogenated solvents, metals, PCBs, pesticides.
Drum Storage Area	42	Composite soil samples from upper six feet and wells if significant contamination is found.	Total petroleum hydrocarbons.
Southeast Landfill	35	Install four wells around site to establish ground water gradient. Adjust program to fit closure requirements.	Total petroleum hydrocarbons, halogenated and nonhalogenated solvents, metals, PCBs, pesticides.
Fuel Storage Area	4	None	NA

Source: ESE, 1984.

2. To insure that the migration of potential contaminants is not promoted through improper land uses;
3. To facilitate the compatible development of future USAF facilities; and
4. To allow for identification of property which may be proposed for excess or outlease.

In general, activities which would tend to disrupt the waste cells should be avoided so as not to facilitate contaminant migration. Such activities include foundation and drainage ditch construction. To avoid trapping any volatile compounds that may be released from the disposal areas, structures should not be placed over the sites.

Recommended land use restrictions are summarized in Tables 6.2-1 and 6.2-2.

Table 6.2-1. Recommended Guidelines at Potential Contamination Sites for Land Use Restrictions
CAFB, San Angelo, Texas

	Recommended Guidelines for Future Land Use Restrictions (1)											
Site	Construction on the Site	Excavation	Well Construction on or near the Site	Agri-cultural Use	Silvi-cultural Use	Water Infiltration (run-on, Ponding, Irrigation)	Recreational Use	Burning or Ignition Source	Disposal Operations	Vehicular Traffic	Material Storage	Housing on or Near the Site
South Landfill	R	R	R	R	NR	R	R	R	R(2)	NR	NR(3)	R
Drum Storage Area	R	NR	R	R	NR	R	R	R	R(2)	NR	NR(3)	R
Southeast Landfill	R	R	R	R	NR	R	R	R	R(2)	NR	NR(3)	R
Fuel Storage Area	NR	NR	NR	NR	NR	NR	NR	NR	R(2)	NR	NR(3)	R

(1) See Table 6.3-2 for description of guidelines.
Note the following symbols in this table:
R = *Restrict the use of the site for this purpose.*
NR = No restriction of the site for this purpose.

(2) Restrict for all wastes except for construction/demolition debris.

(3) No restriction for solid materials but liquids undesirable.

Table 6.2-2. Description of Guidelines for Land Use Restrictions (Page 1 of 2)

Guideline	Description
Construction on the site	Restrict the construction of structures which make permanent (or semi-permanent) and exclusive use of a portion of the site's surface.
Excavation	Restrict the disturbance of the cover of subsurface materials.
Well Construction on or near the site	Restrict the placement of any wells (except for monitoring purposes) on or within a reasonably safe distance of the site. This distance will vary from site to site, based on prevailing soil conditions and groundwater flow.
Agricultural use	Restrict the use of the site for agricultural purposes to prevent food chain contamination.
Silvicultural use	Restrict the use of the site for silvicultural uses (root structures could disturb cover or subsurface materials).
Water infiltration	Restrict water run-on, ponding and/or irrigation of the site. Water infiltration could produce contaminated leachate.
Recreational use	Restrict the use of the site for recreational purposes.
Burning or ignition sources	Restrict any and all unnecessary sources of ignition, due to the possible presence of flammable compounds.
Disposal operations	Restrict the use of the site for waste disposal operations, whether above or below ground.
Vehicular traffic	Restrict the passage of unnecessary vehicular traffic on the site due to the presence of explosive material(s) and/or of an unstable surface.

Table 6.2-2. Description of Guidelines for Land Use Restrictions (Continued, Page 2 of 2)

Guideline	Description
Material storage	Restrict the storage of any and all liquid or solid materials on the site.
Housing on or near the site	Restrict the use of housing structures on or within a reasonably safe distance of the site.

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APPENDIX A

GLOSSARY OF TERMINOLOGY, ABBREVIATIONS, AND ACRONYMS

APPENDIX A
GLOSSARY OF TERMINOLOGY, ABBREVIATIONS, AND ACRONYMS

A Horizon	The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material
AFB	Air Force Base
AFFF	Aqueous Film Forming Foam
AFS	Air Force Station
AG	aboveground
AGE	Aerospace Ground Equipment
AGI	American Geological Institute
Alluvium	Unconsolidated material deposited by stream action.
Aquiclude	Geologic unit which impedes ground water flow
Aquifer	A geologic formation, group of formations, or part of a formation capable of yielding water to a well or spring.
ATC	Air Training Command
B Horizon	The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics such as 1) accumulation of clay, sesquioxides, humus, or a combination of these; 2) prismatic or blocky structure; 3) redder of browner colors than those in the A horizon; or 4) a combination of these. The combined A and B horizons are generally called solum, or true soil. If a soil does not have a B horizon, the A horizon alone is the solum.
BEG	Bureau of Economic Geology, University of Texas at Austin
BES	Bioenvironmental Engineering Services
BX	Base Exchange

APPENDIX A
(Continued, Page 2 of 7)

Cadmium	A metal used in batteries and other industrial applications; highly toxic to humans and aquatic life.
Carbon tetrachloride	A solvent commonly in use until the 1960s; a suspected human carcinogen; fire suppressant.
Carbonate	A sediment formed by the organic or inorganic precipitation from aqueous solutions of calcium, magnesium and iron.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CES	Civil Engineering Squadron
Chert	Dense cryptocrystalline sedimentary rock.
Chromium	A metal used in plating, cleaning, and other industrial applications; highly toxic to aquatic life at low concentrations, toxic to humans at higher levels.
Clastic	Sedimentary rock derived from fragments derived from pre-existing rocks.
Colluvium	Loose material at the base of a steep slope or cliff.
Concretions	Hard, compact material of mineral matter formed by precipitation from aqueous solution.
Conformity	Undisturbed relations of strata deposited in order with little or no time lag, continuous.
Contaminated fuel	Fuel which does not meet specifications for its original use.
Contamination	Degradation of natural water quality to the extent that its usefulness is impared; degree of permissible contamination depends on intended use of water.
Continental rifting	The spreading of continents due to tectonic movement of earth plates.

Coquina	Limestone made up of shells and shell fragments.
Craton	The part of the earth's crust which has attained stability.
DDT	Dichlorodiphenyltrichloroethane, pesticide commonly used in 1960's.
Deposition	The lying down of rock forming material.
DEQPPM	Defense Environmental Quality Program Policy Memorandum
DF	Diesel fuel
Disposal of hazardous waste	Discharge, deposit, injection, dumping, spilling, or placing of any hazardous waste into or on land or water so that such waste or any constituent thereof may enter the environment, be emitted into the air, or be discharged into any waters, including ground water.
DOD	Department of Defense
DPDO	Defense Property Disposal Office
°F	Degrees Fahrenheit
Effluent	Liquid waste discharged in its natural state or partially or completely treated from a manufacturing or treatment process.
EPA	U.S. Environmental Protection Agency
Epeiric	Shallow sea conditions on the continental shelf or within the continent.
Erosion	The breakdown of terrestrial material by natural processes.
ESE	Environmental Science and Engineering, Inc.

APPENDIX A
(Continued, Page 4 of 7)

Eugeosyncline	A large scale structural depression in which volcanism is associated with clastic deposition.
ft	feet
Forland	A stable area marginal to a tectonic belt toward which the rocks of the belt were thrust or overfolded.
GAFB	Goodfellow Air Force Base
gal	gallon
Gilgai	A succession of micro relief structures.
Ground water	Water beneath the land surface in the saturated zone that is under atmospheric or artesian pressure.
HARM	Hazard Assessment Rating Methodology
Hazardous waste	As defined in RCRA, a solid waste or combination of solid wastes which because of its quantity, concentration, or physical, chemical, or infectious characteristics may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness; or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.
HRS	Hazardous Ranking System
IBWC	International Boundary and Water Commission
Igneous	Rock solidified from molten material
in	inches
in/hr	inches per hour

in/yr	inches per year
Infiltration	Movement of water through the soil surface into the ground.
Interformational leakage	Movement of ground water from one aquifer to another due to changes of hydraulic head.
IR	Infrared
IRP	Installation Restoration Program
karst	Topography characterized by depressions or sinkholes caused by solution dissolve of underlying carbonate rocks.
Lead	A metal additive to gasoline and used in other industrial applications; toxic to humans and aquatic life; bioaccumulates.
Leachate	A solution resulting from the separation or dissolving of soluble or particulate constituents from solid waste or other man-placed medium by percolation of water.
loam	Soil material of varible clay, silt and sand compositions.
MEK	Methyl ethyl ketone, a solvent used in paint thinner, stripper, and a wide variety of industrial applications; suspected to be toxic to humans at high levels; potentially toxic to aquatic life.
Metamorphic	Rocks formed from other rock types due to intense temperature and pressure.
µg/l	micrograms per liter
MIBK	methyl isobutyl ketone

AD-A154 713 INSTALLATION RESTORATION PROGRAM PHASE I: RECORDS SEARCH GOODFELLOW AIR FORCE BASE TEXAS(U) ENVIRONMENTAL SCIENCE AND ENGINEERING INC DENVER CO MAR 85 2/2

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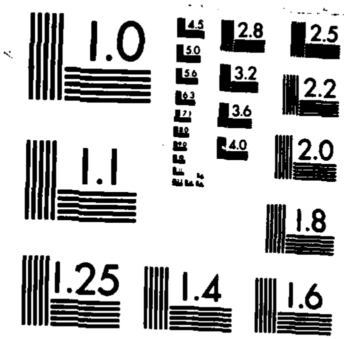


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX A
(Continued, Page 6 of 7)

µmho/cm	micromhos per centimeter
mg/l	milligrams per liter
mm	millimeters
MOGAS	motor gasoline
mph	miles per hour
MWR	Morale, Welfare, and Recreation
orogeny	uplift
PCB	Polychlorinated biphenyls, liquid used as a dielectric in electrical equipment; suspected human carcinogen; bioaccumulates in the food chain and causes toxicity to higher trophic levels.
POL	petroleum, oils, lubricants
ppm	parts per million
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
sedimentary	Rocks formed from consolidation of loose sediment.
Spill	An unplanned release or discharge of a hazardous waste onto or into air, land, or water.
TCE	Trichloroethylene, a commonly used degreasing solvent; toxic to aquatic life and a suspected human carcinogen.
TDWR	Texas Department of Water Resources
UG	underground
unconformity	Break in the depositional record due to uplift and erosion
Upgradient	In the direction of increasing hydraulic static head; the direction opposite to the prevailing flow of ground water.

USAF	U.S. Air Force
USGS	U.S. Geological Survey
USSCS	U.S. Soil Conservation Service
Water table	Surface of a body of unconfined ground water at which the pressure is equal to that of the atmosphere.
WTGS	West Texas Geological Society

APPENDIX B

TEAM MEMBER BIOGRAPHICAL DATA

BRUCE N. McMASTER, Ph D.
Senior Chemist/Project Manager

ESE
PROFESSIONAL RESUME

SPECIALIZATION

Toxic and Hazardous Waste Disposal, Hazardous Waste Site Investigations, Pollutant Fate Studies, Environmental Chemistry, Water Quality

RECENT EXPERIENCE

Records Search for U.S. Army Toxic and Hazardous Materials Agency, Project Manager--Assessing environmental quality of 65 Army installations with regard to the use, storage, treatment and disposal of toxic and hazardous materials; define contaminants present, potential for off-site migration, and potential impacts on receptors; recommend sampling and analysis surveys for quantitative delineation of contamination problems; evaluate compliance status with all applicable environmental regulations.

Environmental Contamination Surveys for the U.S. Army Toxic and Hazardous Materials Agency, Project Manager--Investigating 7 U.S. Army installations to confirm the presence of toxic and hazardous contaminants, and to define the extent of contamination and contaminant migration. Surveys include sampling and analysis of surface waters, ground water, soil, sediments, sewers, and buildings. Conduct alternative analyses for potential mitigative measures.

Initial Assessment Studies for the Naval Energy and Environmental Support Activity, Project Manager--Evaluating 4 Naval installations with regard to past hazardous waste generation, storage, treatment, and disposal practices. Investigations include records review, aerial and ground site surveys, employee interviews, and limited sampling and analysis including geophysical techniques. Determine extent of contamination at former disposal/spill sites, potential for contaminant migration, and potential effects on human health and the environment.

EDUCATION

Post-Doctoral	1977-78	Environmental Engineering/Science	University of Florida
Ph.D.	1976	Chemistry	University of Florida
B.S.	1968	Chemistry	University of Delaware

REGISTRATIONS/ASSOCIATIONS

American Chemical Society, Member
American Defense Preparedness Association, Member

PUBLICATIONS

Approximately 20 hazardous waste site investigations of U.S. military installations.

D-MR1MS.1/BNM-HZ.1
04/27/84

ESE

PROFESSIONAL RESUME

WILLIAM G. FRASER, B.S., P.E.
Senior Associate Engineer

SPECIALIZATION

Water Quality/Resources Engineering, Environmental Impact Assessment, Groundwater Hydrology, Siting and Environmental Studies

RECENT EXPERIENCE

USAF Installation Assessment - Currently evaluating present and historical waste disposal practices at Vance Air Force Base, Oklahoma.

Navy Installation Assessments - Worked as the Environmental Engineer on a project team examining historical waste handling practices and disposal sites at several Naval Bases. Studied waste types and quantities, and assessed disposal site suitability based on hydrogeologic characteristics, neighboring land use, and contaminant migration potential.

Siting Studies - Worked as staff member performing hydrologic, water quality and air quality studies related to siting and licensing of major mining and power facilities.

Field Investigations - Streamflow measurement, water sampling, dam site investigations, and groundwater testing at numerous sites in Colorado and the West.

USATHAMA Installation Assessments - Worked as the Environmental Engineer on a project team examining waste disposal practices at several Army Bases, including Ft. Carson, Colorado. Examined various industrial operations and an industrial waste treatment plant handling oily wastewater.

USATHAMA Environmental Survey - Evaluated the nature and extent of contaminant migration from abandoned landfill sites containing solvents, POL, pesticides, and medical supplies. Reviewed surface and groundwater analytical data and calculated pollutant mass influx at installation boundary based on surface runoff and groundwater flow.

EDUCATION

B.S.	1975	Civil/Environmental Engineering	University of Connecticut

REGISTRATION

Registered Professional Engineer, State of Colorado, 1983

ASSOCIATIONS

American Society of Civil Engineers
American Water Resources Association

ESE

PROFESSIONAL RESUME

KEITH C. GOVRO, M.S.
Group Leader, Ecology

SPECIALIZATION

Ecosystem Impacts from Hazardous Waste Disposal Practices, Wildlife Biology, Fisheries Biology, Water Quality

RECENT EXPERIENCE

Assessment of Hazardous Waste Management/Disposal Practices at U.S. Army Installations, Team Scientist - Performed on-site inspections with regard to the presence of toxic and hazardous materials, the potential for off-site migration of contaminants, and both on-site and off-site waste disposal practices. Evaluations based on review of existing data bases, records and site surveys. Findings used to determine the necessity for confirmatory sampling/analysis and decontamination activities.

Delineation of Habitat Types through Aerial Photo Interpretation, St. Paul District, Corps of Engineers, Project Manager - Delineated habitat types within a 20,000-acre section of the Kickapoo River watershed in southwestern Wisconsin through aerial photo interpretation. Computed acreage for each habitat type by 20-foot contour interval. Resulting data used to determine potential habitat losses associated with the construction of the proposed LaFarge Reservoir.

IQ-ID Contract for Ecological Services, St. Paul District, Corps of Engineers, Project Manager - Contract involves providing aquatic and terrestrial ecological services to the St. Paul District on a work order basis. Past work orders have involved ecological analysis of candidate sites for dredged material placement with Pools 8 and 9 of the Upper Mississippi River.

Biological Inventory of Federal Coal Reserve Area in Southeastern Oklahoma, Bureau of Land Management, Subproject Manager - Conducted field surveys of the vegetation, wildlife and fisheries resources within the 372,000-acre area to provide a data base for assessment of future impacts from mining operations.

Aquatic Ecosystem Surveys, Midwestern Rivers and Reservoirs - Served as Project Manager and/or Project Biologist for numerous aquatic ecology surveys within major Midwestern drainages such as the Mississippi, Illinois, Kaskaskia, Des Moines, Missouri, Wabash and Iowa Rivers and reservoirs such as Lake Hamilton, Lake St. Louis, Lake Springfield, and Newton Lake.

Bioassay of Dredge Spoil Impacts on Aquatic Organisms, U.S. Army Corps of Engineers, Project Scientist - Participated in static and flow-through bioassays assessing impacts to aquatic organisms from exposure to dredge spoils.

EDUCATION

M.S.	1977	Fisheries Biology	Iowa State University
B.S.	1975	Wildlife and Fisheries Biology	Iowa State University

ESE
PROFESSIONAL RESUME

DAVID H. STEPHENS, B.S.
Associate Scientist

SPECIALIZATION

Geologic Evaluations, Geophysical/Geochemical Techniques, Hazardous Waste Site Assessment, Hydrology

RECENT EXPERIENCE

Toxic and Hazardous Materials Assessment Study, Team Geologist--Geologic and hydrologic study of offpost contamination in the area of the Rocky Mountain Arsenal, Denver, Colorado. Tasks included inventory and compilation of geologic and ground water data base, design and maintenance of ground water monitoring and sampling network, and development of subsurface geologic models to aid in the location of additional test borings and construction of hydrologic models.

Geologic and Geohydrologic Evaluation of Air Force Facilities, Team Geologist--Phase I records search as part of installation restoration program. Installations include Laughlin Air Force Base, Del Rio, Texas and Goodfellow Air Force Base, San Angelo, Texas.

Uranium Exploration, Development Drilling, Project Manager--Responsible for entire project management including safety and reclamation activities. Included supervision and monitoring of refuse and waste disposal at onsite locations and compliance with state and federal regulations regarding radioactive materials.

EDUCATION

B.S.	1975	Geological Sciences	Lehigh University

ASSOCIATIONS

American Association of Petroleum Geologists--Energy Minerals Division
Society of Mining Engineers of AIME

DHS/HZ/0884.1
08/13/84

APPENDIX C

LIST OF INTERVIEWEES AND OUTSIDE CONTACTS

APPENDIX C

List of Interviewees

(Page 1 of 3)

Position	Years of Service
Operations	11
Management Consultant	21
Carpenter	21
Planning	1
Refuse - Pavement and Grounds	20
Environmental Coordinator	7
Judge Advocate	5
Clinic	3
Transportation	6
Traffic Manager	7
Fire Department	
Bio Environmental Services	1
Aero Club	4
Auto Hobby	2
CE Shop	32
Fuels/Oils Handling and Storage	5
BX Service Station	2
Real Estate	15
Entron	9
Public Affairs	4
Historian	

APPENDIX C
Outside Contacts
(Continued, Page 2 of 3)

Robert Oregon
Texas National Resources Information Services
P.O. Box 10387
Austin, Texas
(512) 475-3321

Bernie Bake
Texas Department of Water Resources
P.O. Box 78611
Austin, Texas
(512) 475-7036

Kenneth Kruger
Texas Department of Water Resources - San Angelo
224 W. Beauregard
San Angelo, Texas
(915) 655-9479

Jimmy Lee
U.S. Geological Survey
1409 Knickerbocker
San Angelo, Texas
(915) 655-9616

Texas Department of Health
1100 W. 49th St.
Austin, Texas 78756
(512) 458-7271

U.S. Geological Survey Library
1526 Colorado Blvd.
Denver, Colorado 80225
(303) 236-1000

San Angelo Water Department
122 West 1st
San Angelo, Texas 76902
(915) 655-9121

APPENDIX C
Outside Contacts
(Continued, Page 3 of 3)

Tom Green County Health Department
P.O. Box 1757
San Angelo, Texas 76902
(915) 655-9121

Tom Green County Library
113 W. Beauregard
San Angelo, Texas 76902
(915) 655-7321

Jeff Brown
San Angelo Geologic Society
Box 2568
San Angelo, Texas 76901
(915) 658-4535

Texas Parks and Wildlife Department
3407 S. Chadbourne
San Angelo, Texas 70902
(915) 655-2231

APPENDIX D

USAF IRP HAZARD ASSESSMENT RATING METHODOLOGY

HAZARD ASSESSMENT RATING METHODOLOGY FORM
(Continued, Page 2 of 2)

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists, proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for three potential pathways: surface water migration, flooding, and ground water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface water migration				
Distance to nearest surface water	0	8	0	24
Net precipitation	0	6	0	18
Surface erosion	0	8	0	24
Surface permeability	2	6	12	18
Rainfall intensity	2	8	16	24
SUBTOTALS			28	108
Subscore (100 x factor score subtotal/maximum score subtotal)				26
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground water migration				
Depth to ground water	1	8	8	24
Net precipitation	0	6	0	18
Soil permeability	1	8	8	24
Subsurface flows	0	8	0	24
Direct access to ground water	0	8	0	24
SUBTOTALS			16	114
Subscore (100 x factor score subtotal/maximum score subtotal)				14

C. Highest pathway subscore

Enter the highest subscore value from A, B-1, B-2, or B-3 above. Pathways Subscore 26

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors	68
Waste Characteristics	16
Pathways	26
TOTAL	110

divided by 3 = 37 Gross total score

B. Apply factor for waste containment from waste management practices. Gross total score x waste management practices factor = final score.

37 x 0.95 = 35

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of Site: Southeast Landfill

Location: Southeast corner of base - just inside boundary

Date of Operation or Occurrence: 1970 - 1982

Owner/Operator: GAFB - USAF

Comments/Description: General purpose - solid waste

Site Rated By: D.H. Stephens

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	3	10	30	30
C. Land use/zoning within 1-mile radius	3	3	9	9
D. Distance to reservation boundary	3	6	18	18
E. Critical environments within 1-mile radius of site	0	10	0	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	2	6	12	18
I. Population served by ground water supply within 3 miles of site	3	6	18	18
SUBTOTALS			123	180
Receptors subscore (100 x factor score subtotal/maximum score subtotal)				68

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (1=small, 2=medium, 3=large) M
2. Confidence level (1=confirmed, 2=suspected) C
3. Hazard rating (1=low, 2=medium, 3=high) L

Factor Subscore A (from 20 to 100 based on factor score matrix) 40

B. Apply persistence factor:
Factor Subscore A x Persistence Factor = Subscore B
40 x 0.8 = 32

C. Apply physical state multiplier:
Subscore B x Physical State Multiplier = Waste Characteristics Subscore
32 x 0.5 = 16

APPENDIX E

HAZARD ASSESSMENT RATING METHODOLOGY FORMS

TABLE 1 (Continued)

HAZARD ASSESSMENT RATING METHODOLOGY GUIDELINES

IV. WASTE MANAGEMENT PRACTICES CATEGORY

A. This category adjusts the total risk as determined from the receptors, pathways, and waste characteristics categories for waste management practices and engineering controls designed to reduce this risk. The total risk is determined by first averaging the receptors, pathways, and waste characteristics subscores.

B. WASTE MANAGEMENT PRACTICES FACTOR

The following multipliers are then applied to the total risk points (from A):

Waste Management Practice	Multiplier
No containment	1.0
Limited containment	0.95
Fully contained and in full compliance	0.10

Guidelines for fully contained:

Landfills:

- o Clay cap or other impermeable cover
- o Leachate collection system
- o Liners in good condition
- o Adequate monitoring wells

Spills:

- o Quick spill cleanup action taken
- o Contaminated soil removed
- o Soil and/or water samples confirm total cleanup of the spill

Surface Impoundments:

- o Liners in good condition
- o Sound dikes and adequate freeboard
- o Adequate monitoring wells

Fire Proection Training Areas:

- o Concrete surface and berms
- o Oil/water separator for pretreatment of runoff
- o Effluent from oil/water separator to treatment plant

General Note: If data are not available or known to be complete the factor ratings under items I-A through I, III-B-1 or III-B-3, then leave blank for calculation of factor score and maximum possible score.

III. PATHWAYS CATEGORY

A. Evidence of Contamination

Direct evidence is obtained from laboratory analyses of hazardous contaminants present above natural background levels in surface water, ground water, or air. Evidence should confirm that the source of contamination is the site being evaluated.

Indirect evidence might be from visual observation (i.e., leachate), vegetation stress, sludge deposits, presence of taste and odors in drinking water, or reported discharges that cannot be directly confirmed as resulting from the site, but the site is greatly suspected of being a source of contamination.

B-1 POTENTIAL FOR SURFACE WATER CONTAMINATION

Rating Factor	Rating Scale Levels: 0	1	2	3	Multiplier
Distance to nearest surface water (includes drainage ditches and storm sewers)	Greater than 1 mile	2,001 feet to 1 mile	501 feet to 2,000 feet	0 to 500 feet	8
Net precipitation	Less than -10 in.	-10 to + 5 in.	+5 to +20 in.	Greater than +20 in.	6
Surface erosion	None	Slight	Moderate	Severe	8
Surface permeability	0% to 15% clay ($>10^{-2}$ cm/sec)	15% to 30% clay (10^{-2} to 10^{-4} cm/sec)	30% to 50% clay (10^{-4} to 10^{-6} cm/sec)	Greater than 50% clay ($<10^{-6}$ cm/sec)	6
Rainfall intensity based on 1 year 24-hr rainfall	<1.0 inch	1.0-2.0 inches	2.1-3.0 inches	>3.0 inches	8

B-2 POTENTIAL FOR FLOODING

Rating Factor	0	1	2	3	Multiplier
Floodplain	Beyond 100-year floodplain	In 25-year floodplain	In 10-year floodplain	Floods annually	1

B-3 POTENTIAL FOR GROUND-WATER CONTAMINATION

Rating Factor	0	1	2	3	Multiplier
Depth to ground water	Greater than 500 ft	50 to 500 feet	11 to 50 feet	0 to 10 feet	8
Net precipitation	Less than -10 in.	-10 to +5 in.	+5 to +20 in.	Greater than +20 in.	6
Soil permeability	Greater than 50% clay ($>10^{-6}$ cm/sec)	30% to 50% clay (10^{-4} to 10^{-6} cm/sec)	15% to 30% clay (10^{-2} to 10^{-4} cm/sec)	0% to 15% clay ($<10^{-2}$ cm/sec)	8
Subsurface flows	Bottom of site greater than 5 feet above high ground-water level	Bottom of site occasionally submerged	Bottom of site frequently submerged	Bottom of site located below mean ground-water level	8
Direct access to ground water (through faults, fractures, faulty well casings, subsidence fissures, etc.)	No evidence of risk	Low risk	Moderate risk	High risk	8

II. WASTE CHARACTERISTICS (Continued)

Waste Characteristics Matrix

Point Rating	Hazardous Waste Quantity	Confidence Level of Information	Hazard Rating
100	L	C	H
80	L	C	M
	M	C	H
70	L	S	H
60	S	C	H
	M	C	M
50	L	S	M
	L	C	L
	M	S	H
	S	C	M
40	S	S	H
	M	S	M
	M	C	L
	L	S	L
30	S	C	L
	M	S	L
	S	S	M
20	S	S	L

Notes:
For a site with more than one hazardous waste, the waste quantities may be added using the following rules:
Confidence Level
- o Confirmed confidence levels (C) can be added
- o Suspected confidence levels (S) can be added
- o Confirmed confidence levels cannot be added with suspected confidence levels

Waste Hazard Rating
- o Wastes with the same hazard rating can be added
- o Wastes with different hazard ratings can only be added in a downgrade mode, e.g., MCM + SCH = LCM if the total quantity is greater than 20 tons.

Example: Several wastes may be present at a site, each having an MCM designation (60 points). By adding the quantities of each waste, the designation may change to LCM (80 points). In this case, the correct point rating for the waste is 80.

B. Persistence Multiplier for Point Rating

Persistence Criteria	Multiply Point Rating From Part A by the Following
Metals, polycyclic compounds, and halogenated hydrocarbons	1.0
Substituted and other ring compounds	0.9
Straight chain hydrocarbons	0.8
Easily biodegradable compounds	0.4

C. Physical State Multiplier

Physical State	Multiply Point Total From Parts A and B by the Following
Liquid	1.0
Sludge	0.75
Solid	0.50

TABLE 1 (Continued)

HAZARD ASSESSMENT RATING METHODOLOGY GUIDELINES

II. WASTE CHARACTERISTICS

A-1 Hazardous Waste Quantity

S = Small quantity (<5 tons or 20 drums of liquid)
M = Moderate quantity (5 to 20 tons or 21 to 85 drums of liquid)
L = Large quantity (>20 tons or 85 drums of liquid)

A-2 Confidence Level of Information

C = Confirmed confidence level (minimum criteria below)

- o Verbal reports from interviewer (at least 2) or written information from the records.
- o Knowledge of types and quantities of wastes generated by shops and other areas on base.
- o Based on the above, a determination of the types and quantities of waste disposed of at the site.

S = Suspected confidence level

- o No verbal reports or conflicting verbal reports and no written information from the records.
- o Logic based on a knowledge of the types and quantities of hazardous wastes generated at the base, and a history of past waste disposal practices indicate that these wastes were disposed of at a site.

A-3 Hazard Rating

Hazard Category	Rating Scale Levels 0	1	2	3
Toxicity	Sax's Level 0	Sax's Level 1	Sax's Level 2	Sax's Level 3
Ignitability	Flash point greater than 200°F	Flash point at 140°F to 200°F	Flash point at 80°F to 140°F	Flash point less than 80°F
Radioactivity	At or below background levels	1 to 3 times background levels	3 to 5 times background levels	Over 5 times background levels

Use the highest individual rating based on toxicity, ignitability and radioactivity and determine the hazard rating.

Hazard Rating	Points
High (H)	3
Medium (M)	2
Low (L)	1

TABLE 1

HAZARD ASSESSMENT RATING METHODOLOGY GUIDELINES

I. RECEPTORS CATEGORY

Rating Factors	Rating Scale Levels 0	1	2	3	Multiplier
A. Population within 1,000 feet (includes on-base facilities)	0	1 - 25	26 - 100	Greater than 100	4
B. Distance to nearest water well	Greater than 3 miles	1 to 3 miles	3,001 feet to 1 mile	0 to 3,000 feet	10
C. Land Use/Zoning (within 1 mile radius)	Completely remote (zoning not applicable)	Agricultural	Commercial or industrial	Residential	3
D. Distance to installation boundary	Greater than 2 miles	1 to 2 miles	1,001 feet to 1 mile	0 to 1,000 feet	6
E. Critical environments (within 1 mile radius)	Not a critical environment	Natural areas	Pristine natural areas; minor wetlands; preserved areas; presence of economically important natural resources susceptible to contamination.	Major habitat of an endangered or threatened species; presence of recharge area; major wetlands.	10
F. Water quality/use designation of nearest surface water body	Agricultural or industrial use.	Recreation, propagation and management of fish and wildlife.	Shellfish propagation and harvesting.	Potable water supplies	6
G. Ground-Water use of uppermost aquifer	Not used, other sources readily available.	Commercial, industrial, or irrigation, very limited other water sources.	Drinking water, municipal water available.	Drinking water, no municipal water available; commercial, industrial, or irrigation, no other water source available.	9
H. Population served by surface water supplies within 3 miles downstream of site	0	1 - 50	51 - 1,000	Greater than 1,000	6
I. Population served by aquifer supplies within 3 miles of site	0	1 - 50	51 - 1,000	Greater than 1, 000	6

FIGURE 2 (Continued)

III. PATHWAYS

Rating Factor	Factor Rating (0-3)	Multiplier	Factor Score	Maximum Possible Score

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore ______

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating, and proceed to C.

1. Surface water migration

Rating Factor	Factor Rating (0-3)	Multiplier	Factor Score	Maximum Possible Score
Distance to nearest surface water		8		
Net precipitation		6		
Surface erosion		8		
Surface permeability		6		
Rainfall intensity		8		

Subtotals ______ ______

Subscore (100 X factor score subtotal/maximum score subtotal) ______

2. Flooding

Rating Factor	Factor Rating (0-3)	Multiplier	Factor Score	Maximum Possible Score
Flooding		1		

Subscore (100 x factor score/3) ______

3. Ground-water migration

Rating Factor	Factor Rating (0-3)	Multiplier	Factor Score	Maximum Possible Score
Depth to ground water		8		
Net precipitation		6		
Soil permeability		8		
Subsurface flows		8		
Direct access to ground water		8		

Subtotals ______ ______

Subscore (100 x factor score subtotal/maximum score subtotal) ______

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore ______

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors ______
Waste Characteristics ______
Pathways ______

Total ______ divided by 3 = ______
Gross Total Score

B. Apply factor for waste containment from waste management practices

Gross Total Score X Waste Management Practices Factor = Final Score

______ X ______ = ______

FIGURE 2

HAZARD ASSESSMENT RATING METHODOLOGY FORM

NAME OF SITE ______

LOCATION ______

DATE OF OPERATION OR OCCURRENCE ______

OWNER/OPERATOR ______

COMMENTS/DESCRIPTION ______

SITE RATED BY ______

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multiplier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site		4		
B. Distance to nearest well		10		
C. Land use/zoning within 1 mile radius		3		
D. Distance to reservation boundary		6		
E. Critical environments within 1 mile radius of site		10		
F. Water quality of nearest surface water body		6		
G. Ground water use of uppermost aquifer		9		
H. Population served by surface water supply within 3 miles downstream of site		6		
I. Population served by ground-water supply within 3 miles of site		6		
		Subtotals	______	______

Receptors subscore (100 X factor score subtotal/maximum score subtotal) ______

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (S = small, M = medium, L = large) ______
2. Confidence level (C = confirmed, S = suspected) ______
3. Hazard rating (H = high, M = medium, L = low) ______

Factor Subscore A (from 20 to 100 based on factor score matrix) ______

B. Apply persistence factor
Factor Subscore A X Persistence Factor = Subscore B

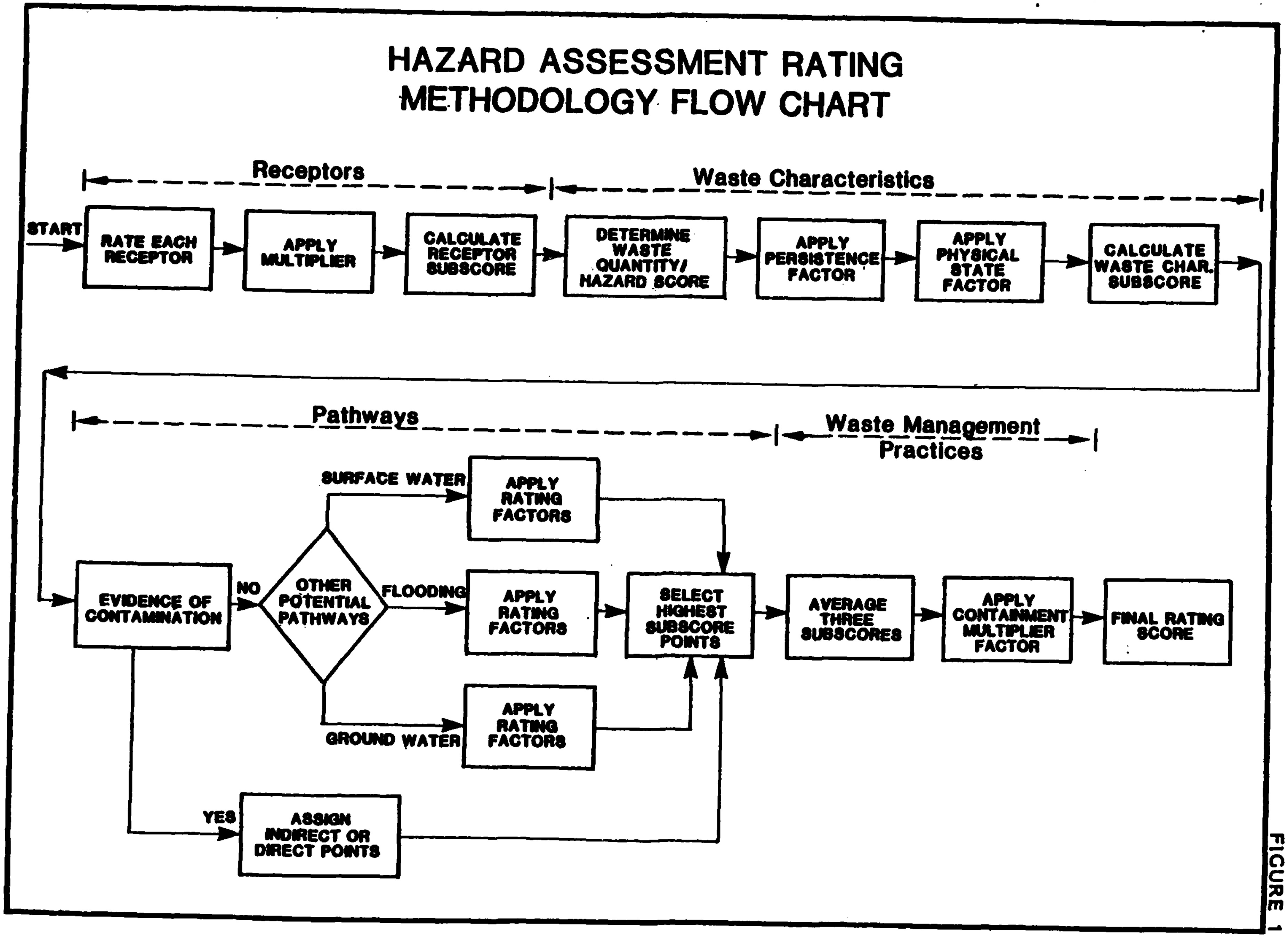
______ X ______ = ______

C. Apply physical state multiplier

Subscore B X Physical State Multiplier = Waste Characteristics Subscore

______ X ______ = ______

FIGURE 1


HAZARD ASSESSMENT RATING
METHODOLOGY FLOW CHART
Receptors
Waste Characteristics
START
RATE EACH RECEPTOR
APPLY MULTIPLIER
CALCULATE RECEPTOR SUBSCORE
DETERMINE WASTE QUANTITY/ HAZARD SCORE
APPLY PERSISTENCE FACTOR
APPLY PHYSICAL STATE FACTOR
CALCULATE WASTE CHAR. SUBSCORE
Pathways
Waste Management Practices
EVIDENCE OF CONTAMINATION
NO
OTHER POTENTIAL PATHWAYS
SURFACE WATER
FLOODING
GROUND WATER
APPLY RATING FACTORS
APPLY RATING FACTORS
APPLY RATING FACTORS
SELECT HIGHEST SUBSCORE POINTS
AVERAGE THREE SUBSCORES
APPLY CONTAINMENT MULTIPLIER FACTOR
FINAL RATING SCORE
YES
ASSIGN INDIRECT OR DIRECT POINTS

The pathways category rating is based on evidence of contaminant migration or an evaluation of the highest potential (worst case) for contaminant migration along one of three pathways. If evidence of contaminant migration exists, the category is given a subscore of 80 to 100 points. For indirect evidence, 80 points are assigned and for direct evidence 100 points are assigned. If no evidence is found, the highest score among three possible routes is used. These routes are surface water migration, flooding, and ground-water migration. Evaluation of each route involves factors associated with the particular migration route. The three pathways are evaluated and the highest score among all four of the potential scores is used.

The waste characteristics category is scored in three steps. First, a point rating is assigned based on an assessment of the waste quantity and the hazard (worst case) associated with the site. The level of confidence in the information is also factored into the assessment. Next, the score is multiplied by a waste persistence factor, which acts to reduce the score if the waste is not very persistent. Finally, the score is further modified by the physical state of the waste. Liquid wastes receive the maximum score, while scores for sludges and solids are reduced.

The scores for each of the three categories are then added together and normalized to a maximum possible score of 100. Then the waste management practice category is scored. Sites at which there is no containment are not reduced in score. Scores for sites with limited containment can be reduced by 5 percent. If a site is contained and well managed, its score can be reduced by 90 percent. The final site score is calculated by applying the waste managment practices category factor to the sum of the scores for the other three categories.

PURPOSE

The purpose of the site rating model is to provide a relative ranking of sites of suspected contamination from hazardous substances. This model will assist the Air Force in setting priorities for follow-on site investigations and confirmation work under Phase II of IRP.

This rating system is used only after it has been determined that (1) potential for contamination exists (hazardous wastes present in sufficient quantity), and (2) potential for migration exists. A site can be deleted from consideration for rating on either basis.

DESCRIPTION OF MODEL

Like the other hazardous waste site ranking models, the U.S. Air Force's site rating model uses a scoring system to rank sites for priority attention. However, in developing this model, the designers incorporated some special features to meet specific DOD program needs.

The model uses data readily obtained during the Record Search portion (Phase I) of the IRP. Scoring judgments and computations are easily made. In assessing the hazards at a given site, the model develops a score based on the most likely routes of contamination and the worst hazards at the site. Sites are given low scores only if there are clearly no hazards at the site. This approach meshes well with the policy for evaluating and setting restrictions on excess DOD properties.

As with the previous model, this model considers four aspects of the hazard posed by a specific site: the possible receptors of the contamination, the waste and its characteristics, potential pathways for waste contaminant migration, and any efforts to contain the contaminants. Each of these categories contains a number of rating factors that are used in the overall hazard rating.

The receptors category rating is calculated by scoring each factor, multiplying by a factor weighting constant and adding the weighted scores to obtain a total category score.

USAF INSTALLATION RESTORATION PROGRAM

HAZARD ASSESSMENT RATING METHODOLOGY

BACKGROUND

The Department of Defense (DOD) has established a comprehensive program to identify, evaluate, and control problems associated with past disposal practices at DOD facilities. One of the actions required under this program is to:

> "develop and maintain a priority listing of contaminated installations and facilities for remedial action based on potential hazard to public health, welfare, and environmental impacts." (Reference: DEQPPM 81-5, 11 December 1981).

Accordingly, the United States Air Force (USAF) has sought to establish a system to set priorities for taking further actions at sites based upon information gathered during the Records Search phase of its Installation Restoration Program (IRP).

The first site rating model was developed in June 1981 at a meeting with representatives from USAF Occupational Environmental Health Laboratory (OEHL), Air Force Engineering Services Center (AFESC), Engineering-Science (ES) and CH_2M Hill. The basis for this model was a system developed for EPA by JRB Associates of McLean, Virginia. The JRB model was modified to meet Air Force needs.

After using this model for 6 months at over 20 Air Force installations, certain inadequacies became apparent. Therefore, on January 26 and 27, 1982, representatives of USAF OEHL, AFESC, various major commands, Engineering Science, and CH_2M Hill met to address the inadequacies. The result of the meeting was a new site rating model designed to present a better picture of the hazards posed by sites at Air Force installations. The new rating model described in this presentation is referred to as the Hazard Assessment Rating Methodology.

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of Site: Drum Storage Area

Location: Inside north boundary at Avenue C

Date of Operation or Occurrence: 1950 - 1956

Owner/Operator: GAFB - USAF

Comments/Description: Storage of drummed liquids and residues

Site Rated By: D.H. Stephens

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	3	10	30	30
C. Land use/zoning within 1-mile radius	3	3	9	9
D. Distance to reservation boundary	3	6	18	18
E. Critical environments within 1-mile radius of site	0	10	0	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	3	6	18	18
I. Population served by ground water supply within 3 miles of site	2	6	12	18
SUBTOTALS			123	180
Receptors subscore (100 x factor score subtotal/maximum score subtotal)				68

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (1=small, 2=medium, 3=large) M
2. Confidence level (1=confirmed, 2=suspected) S
3. Hazard rating (1=low, 2=medium, 3=high) M

Factor Subscore A (from 20 to 100 based on factor score matrix) 40

B. Apply persistence factor:
Factor Subscore A x Persistence Factor = Subscore B
40 x 0.8 = 32

C. Apply physical state multiplier:
Subscore B x Physical State Multiplier = Waste Characteristics Subscore
32 x 1.0 = 32

HAZARD ASSESSMENT RATING METHODOLOGY FORM
(Continued, Page 2 of 2)

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists, proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for three potential pathways: surface water migration, flooding, and ground water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface water migration				
Distance to nearest surface water	1	8	8	24
Net precipitation	0	6	0	18
Surface erosion	0	8	0	24
Surface permeability	2	6	12	18
Rainfall intensity	2	8	16	24
SUBTOTALS			36	108
Subscore (100 x factor score subtotal/maximum score subtotal)				33
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	1	8	8	24
Subsurface flows	0	8	8	24
Direct access to ground water	0	8	0	24
SUBTOTALS			32	114
Subscore (100 x factor score subtotal/maximum score subtotal)				28

C. Highest pathway subscore

Enter the highest subscore value from A, B-1, B-2, or B-3 above.

Pathways Subscore 33

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors	68
Waste Characteristics	32
Pathways	33
TOTAL	133 divided by 3 = 44 Gross total score

B. Apply factor for waste containment from waste management practices. Gross total score x waste management practices factor = final score.

44 x 0.95 = 42

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of Site: South Landfill

Location: Extreme south end of base - Chadbourne Road

Date of Operation or Occurrence: 1950 - Present

Owner/Operator: GAFB - USAF

Comments/Description: Currently rubble dump - past G.P. dump

Site Rated By: D.H. Stephens

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	3	10	30	30
C. Land use/zoning within 1-mile radius	3	3	9	9
D. Distance to reservation boundary	3	6	18	18
E. Critical environments within 1-mile radius of site	0	10	0	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	2	6	12	18
I. Population served by ground water supply within 3 miles of site	3	6	18	18
SUBTOTALS			124	180
Receptors subscore (100 x factor score subtotal/maximum score subtotal)				68

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (1=small, 2=medium, 3=large) L
2. Confidence level (1=confirmed, 2=suspected) C
3. Hazard rating (1=low, 2=medium, 3=high) H

Factor Subscore A (from 20 to 100 based on factor score matrix) 100

B. Apply persistence factor:
Factor Subscore A x Persistence Factor = Subscore B
100 x 0.8 = 80

C. Apply physical state multiplier:
Subscore B x Physical State Multiplier = Waste Characteristics Subscore
80 x 1.0 = 80

HAZARD ASSESSMENT RATING METHODOLOGY FORM
(Continued, Page 2 of 2)

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists, proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for three potential pathways: surface water migration, flooding, and ground water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface water migration				
Distance to nearest surface water	0	8	0	24
Net precipitation	0	6	0	18
Surface erosion	0	8	0	24
Surface permeability	2	6	12	18
Rainfall intensity	2	8	16	24
SUBTOTALS			28	108
Subscore (100 x factor score subtotal/maximum score subtotal)				26
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground water migration				
Depth to ground water	1	8	8	24
Net precipitation	0	6	0	18
Soil permeability	1	8	8	24
Subsurface flows	0	8	0	24
Direct access to ground water	0	8	0	24
SUBTOTALS			16	114
Subscore (100 x factor score subtotal/maximum score subtotal)				14

C. Highest pathway subscore

Enter the highest subscore value from A, B-1, B-2, or B-3 above. Pathways Subscore 26

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors	68
Waste Characteristics	80
Pathways	26
TOTAL	174

divided by 3 = 58 Gross total score

B. Apply factor for waste containment from waste management practices. Gross total score x waste management practices factor = final score.

58 x 1.0 = 58

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of Site: Fuel Storage Area

Location: Just North of existing Building 300

Date of Operation or Occurrence: 1941-1958

Owner/Operator: GAFB-USAF

Comments/Description: Main Aircraft Fuel Storage Area

Site Rated By: D.H. Stephens

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multiplier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	2	10	20	30
C. Land use/zoning within 1-mile radius	3	3	9	9
D. Distance to reservation boundary	2	6	12	18
E. Critical environments within 1-mile radius of site	0	10	0	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	3	6	18	18
I. Population served by ground water supply within 3 miles of site	2	6	12	18
SUBTOTALS			107	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 59

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (1=small, 2=medium, 3=large) L
2. Confidence level (1=confirmed, 2=suspected) S
3. Hazard rating (1=low, 2=medium, 3=high) M

Factor Subscore A (from 20 to 100 based on factor score matrix) 50

B. Apply persistence factor:
Factor Subscore A x Persistence Factor = Subscore B
50 x 0.8 = 40

C. Apply physical state multiplier:
Subscore B x Physical State Multiplier = Waste Characteristics Subscore
40 x 1.0 = 40

HAZARD ASSESSMENT RATING METHODOLOGY FORM
(Continued, Page 2 of 2)

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists, proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for three potential pathways: surface water migration, flooding, and ground water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface water migration				
Distance to nearest surface water	1	8	8	24
Net precipitation	0	6	0	18
Surface erosion	0	8	8	24
Surface permeability	0	6	0	18
Rainfall intensity	2	8	16	24
SUBTOTALS			24	108
Subscore (100 x factor score subtotal/maximum score subtotal)				22
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	1	8	8	24
Subsurface flows	0	8	8	24
Direct access to ground water	0	8	0	24
SUBTOTALS			32	114
Subscore (100 x factor score subtotal/maximum score subtotal)				28

C. Highest pathway subscore

Enter the highest subscore value from A, B-1, B-2, or B-3 above. Pathways Subscore 28

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors	59
Waste Characteristics	40
Pathways	28
TOTAL	127

divided by 3 = 42 Gross total score

B. Apply factor for waste containment from waste management practices. Gross total score x waste management practices factor = final score.

42 x 0.10 = 4

END

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